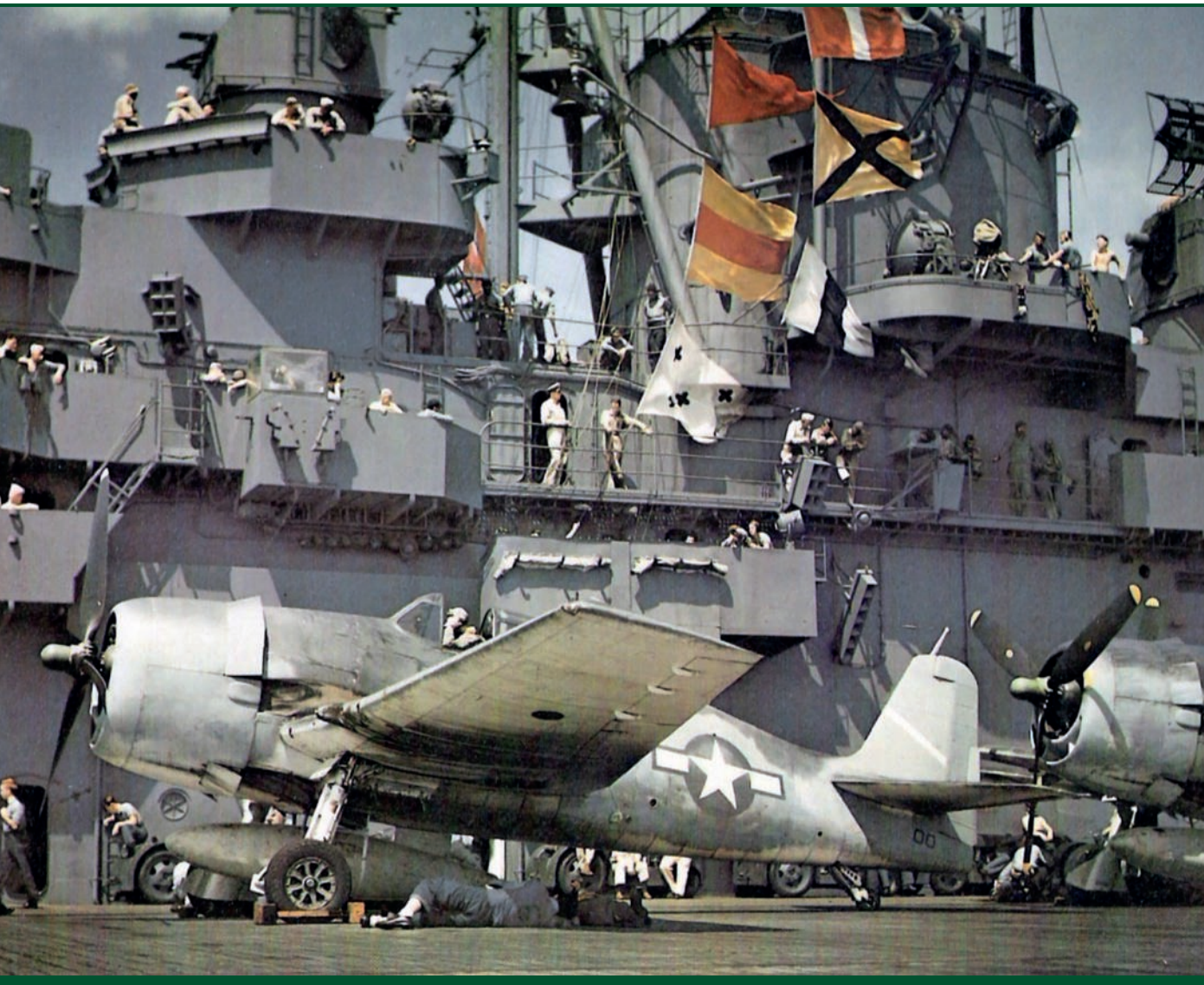
World War II US Fast Carrier Task Force Tactics 1943–45



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World War II US Fast Carrier Task Force Tactics 1943–45

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Series editor Martin Windrow

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WORLD WAR II US FAST CARRIER TASK FORCE TACTICS 1943–45

INTRODUCTION

By November 1943, the prewar US fleet so devastated in 1941 and 1942 had become a dimming memory. Replacing it was an essentially brand-new navy whose warships were being churned out by the United States' surging industrial mobilization. The new navy's crown jewel was the **Fast Carrier Task Force**, a combined-arms weapons system comprising modern aircraft carriers embarking fighters and bombers, battleships, cruisers, and destroyers, tied together by new technologies and tactics, and manned by overwhelmingly new personnel.

While the US Navy deployed many fast carrier task forces in World War II, including occasionally in the Atlantic, only one formation became known simply as *the* Fast Carrier Task Force. Between November 1943 and August 1945 this single battle fleet had several commanders and designations, but remains best-remembered as Vice Admiral Marc Mitscher's Task Force 58 (TF-58). Numerous volumes have analyzed the warships, aircraft, campaigns, and admirals of the FCTF; this book will instead address the structure, doctrine, and tactics of this powerful strike fleet.

The light carrier USS *Langley* (CVL-27) leads Task Group 38.3 into the Ulithi anchorage in the Caroline Islands on December 12, 1944, followed by the heavy carrier *Ticonderoga* (CV-14), battleships *Washington* (BB-56), *North Carolina* (BB-55), and *South Dakota* (BB-57), and light cruisers *Santa Fe* (CL-60), *Biloxi* (CL-80), *Mobile* (CL-63), and *Oakland* (CL-95). This imposing line of US carriers, battleships, and cruisers symbolically suggests the US Pacific Fleet commanders' dream of a combined air-surface "fleet battle," which ultimately never transpired – largely due to the carriers' vastly superior ship-killing range compared to that of all surface warships, supported by the sophisticated application of radar technology. (Navsource)

Admiral Halsey's Iowa-class battleship USS *New Jersey* (BB-62) and Vice Adm McCain's Essex-class carrier USS *Hancock* (CV-19) in high seas, November 1944. To counter Japan's 26-knot Kongo-class battleships, the USN conceived an independent fast battleship/fast carrier striking force, resulting in the 33-knot Iowa-class battleships authorized in 1938. The never-realized independent striking force conceptually preceded the Fast Carrier Task Force, demonstrating that the USN's operational revolution from the "fleet battle" toward swift strikes pre-dated Pearl Harbor. In practice, by 1945 any chance of a battle-line duel with IJN heavy warships had come and gone. (Navsource)

From November 1943 to the end of the war the US Pacific Fleet's offensive spearhead was the Fast Carrier Task Force, a high-speed battle fleet comprising three to five carrier **Task Groups,** each cruising in a 4- to 6-mile wide circular formation centered on three or four fast carriers – typically two Essex-class carriers and one or two Independence-class light carriers. (Note that all distances given in this text are in nautical miles – see conversion factor on page 2.) Surrounding the fast carriers in an inner ring were two to three fast battleships, and four to five cruisers. A screen of 16–20 destroyers maintained the outermost ring. The Task Groups themselves cruised 12nm apart center-to-center, each Task Group being commanded by a rear admiral. Task Group carriers, battleships, and cruisers were grouped together by type into **divisions**; carrier division commanders simultaneously commanded their carriers' respective Task Group. Destroyers were grouped into **squadrons** comprising multiple divisions. Above individual ships, the division was the smallest tactical and administrative unit.

COMPOSITION

Fast carriers

By 1943 the US Navy operated two carrier types: 30-plus knot **fast carriers** (also called **fleet carriers**) intended for high-intensity offensive combat, and 18-knot **escort carriers** that performed anti-submarine warfare (ASW), amphibious air support, and aircraft ferrying duties. While their operations supported each other, fast carriers and escort carriers typically operated separately, and only the former are the subject of this book.

The American tradition of large, fast fleet carriers was established by the 1920–27 conversions of the 874-foot, 44,200-ton *Lexington* and *Saratoga* battlecruiser hulls into high-speed aircraft carriers. Being large and fast imparted significant tactical and operational advantages. At 34.5 knots, the Lexingtons could outrun surface and submarine threats that they couldn't fight (for speed conversion factor, see page 2). High speed additionally facilitated launch and recovery operations, while by

Freshly-painted in Measure 21 camouflage, USS *Yorktown* (CV-10) is seen at Norfolk during her April 15, 1943 commissioning. The sheer size of the Essex-class fleet carrier is obvious. An Essex transiting the Panama Canal produced "much squalling of tortured steel and scraping of unyielding concrete," while the carrier's gun tubs and high, 140ft-wide flight deck "regularly mowed down … concrete lampposts well clear of a lock's sides." Even so, this class's tactical diameter (turning circle) was only 765 yards at a speed of 30 knots. The Essex class was designed for a crew of 2,386 (215 officers and 2,171 enlisted), but by 1945 complements had swollen to 3,448. This improved fighting efficiency, but cramped the living conditions. (US Navy)

1936 the Lexingtons' huge size allowed them to carry up to 109 biplanes each. After experimenting with the 29-knot, 14,810-ton USS *Ranger* (CV-4), commissioned in 1934, the USN ultimately concluded large, fast carriers were more efficient than smaller ones. Aside from the 29.5-knot, 14,700-ton USS *Wasp* (CV-7) – a special design commissioned in 1940 to employ remaining treaty tonnage – US fleet carriers were designed for large air groups and high speed.

Large carriers were hull type-designated **CV**. Carrying 90-plus aircraft, the 33-knot, 27,500-ton CV-9 Essex class provided the backbone of the 1943–1945 FCTF. The Essexes were larger, improved Yorktowns, well-balanced between speed, survivability, and striking power, with a theoretical maximum range of 15,440nm at an optimal 15 knots (although, given the USN's mastery of at-sea replenishment – see "Strategy and logistics" below – such figures were almost meaningless in practice). Fourteen saw action during World War II. The Essexes were augmented by two 1942 survivors, the 34.5-knot, 36,000-ton Lexington-class carrier USS *Saratoga* (CV-3) and the 33-knot, 20,000-ton Yorktown-class carrier USS *Enterprise* (CV-6).

The Fast Carrier Task Force was filled out by nine 31.5-knot, 11,000-ton Independence-class light carriers, type-designated **CVL**. These were a pet project of Franklin Roosevelt, who in October 1941 had noticed that the first Essexes were not expected in commission until 1944. Overcoming the Navy's reluctance, Roosevelt insisted several Cleveland-class light cruisers be completed as austere fast carriers as a wartime expedient to bridge the gap. As expected, the resulting Independences were inferior to large carriers, being cramped, poorly armored, more challenging to fly from, and carrying only 33 aircraft – one-third of the air group accommodated by the Essexes. However, they were fast hulls that could be converted quickly, and wartime developments proved Roosevelt's intuition correct.

US Fast Carriers 1943–45			
Carrier	**Class**	**Commissioned**	**Deployed FCTF**
CV-3 *Saratoga*	Lexington	Nov 1927	Nov 1943
CV-6 *Enterprise*	Yorktown	May 1938	Nov 1943
CV-9 *Essex*	Essex	Dec 1942	Nov 1943
CV-10 *Yorktown*	Essex	Apr 1943	Nov 1943
CV-16 *Lexington*	Essex	Feb 1943	Nov 1943
CV-17 *Bunker Hill*	Essex	May 1943	Nov 1943
CVL-22 *Independence*	Independence	Jan 1943	Nov 1943
CVL-23 *Princeton*	Independence	Feb 1943	Nov 1943
CVL-24 *Belleau Wood*	Independence	Mar 1943	Nov 1943
CVL-25 *Cowpens*	Independence	May 1943	Nov 1943
CVL-26 *Monterey*	Independence	June 1943	Nov 1943
CV-11 *Intrepid*	Essex	Aug 1943	Jan 1944
CVL-27 *Langley*	Independence	Aug 1943	Jan 1944
CVL-28 *Cabot*	Independence	July 1943	Jan 1944
CV-12 *Hornet*	Essex	Nov 1943	Mar 1944
CVL-29 *Bataan*	Independence	Nov 1943	Apr 1944
CV-18 *Wasp*	Essex	Nov 1943	May 1944
CVL-30 *San Jacinto*	Independence	Nov 1943	May 1944
CV-13 *Franklin*	Essex	Jan 1944	June 1944
CV-14 *Ticonderoga*	Essex	May 1944	Oct 1944
CV-19 *Hancock*	Essex	Apr 1944	Oct 1944
CV-15 *Randolph*	Essex	Oct 1944	Feb 1945
CV-20 *Bennington*	Essex	Aug 1944	Feb 1945
CV-38 *Shangri-La*	Essex	Sept 1944	Apr 1945
CV-31 *Bonhomme Richard*	Essex	Nov 1944	June 1945

Escorts

The FCTF was composed overwhelmingly of state-of-the-art vessels of wartime construction; by 1945 few ships were more than three years old. However, wartime proliferation of radars, anti-aircraft batteries, and additional crew far beyond original designs resulted in cramped, often dangerously top-heavy ships by 1945.

The fast carriers' most powerful escorts were the ten **fast battleships (BB)** of the North Carolina (36,600-ton), South Dakota (35,000-ton), and Iowa (45,000-ton) classes commissioned between 1941 and 1944. Armed with 9x 16-inch and 20x 5-inch/38 DP (dual-purpose) guns, at 28–33 knots the fast battleships could maintain formation with the fast carriers. With their heavy anti-aircraft battery, fast battleships were the FCTF's supreme anti-aircraft platforms. In addition to defending the Task Force against potential surface attack, fast battleships expected to fight offensive surface actions beneath air cover provided by their carriers when circumstances were favorable. Unlike carriers, fast battleships could fight at night and in poor weather, as well as physically protecting from surface attacks such geographic locations as amphibious beachheads, straits, and open sea between the fast carriers and a hostile fleet.

Besides anti-aircraft support, **heavy cruisers (CA)** provided long-range stopping power during potential night-time surface actions; their slow-firing but radar-directed 8-inch battery was expected to keep enemy surface units beyond effective torpedo range. While many prewar heavy cruisers also served, the FCTF's standard heavy cruiser was the 33-knot, 14,472-ton Baltimore

An antiaircraft drill aboard the battleship USS *Missouri* (BB-63). In the foreground is the Sky Platform where the air defense officer conducts operations in front of repeater displays; to the officer's left is a sky lookout. Three 20mm Oerlikons are identified by plumes of smoke at the right, and a quad 40mm Bofors is mounted atop the No. 2 16-inch turret. (Navsource)

class, commissioned in 1943–45, armed with 9x 8-inch/55 guns and 12x 5-inch/38 DP guns. In early 1945 the two freakish 33-knot, 29,771-ton Alaska-class "large cruisers" (**CB**) arrived. These mounted 9x 12-inch/50 guns and 12x 5-inch/38 DP guns, but performed the same role as the Baltimores.

Light cruisers (**CL**) also screened fast carriers from air attack. During a surface battle the light cruisers would be used offensively, employing their fast-firing 6-inch guns to punch through the enemy screen, and setting up US destroyers to make torpedo runs on the enemy battle line. The standard light cruiser of the FCTF was the 32.5 knot, 11,744-ton Cleveland class, commissioned in 1942–45 and armed with 12x 6-inch/47 guns and 12x 5-inch/38 DP guns. During a surface battle a Cleveland could unleash 120 shells from its 6-inch guns per minute. The 33-knot, 6,590-ton Atlanta-Oakland-class light cruisers were commissioned in 1941–45. Although intended as torpedo-armed destroyer leaders, the Atlanta-Oaklands' heavy battery of 16x 5-inch/38 DP guns prompted their use as unofficial anti-aircraft cruisers.

US Fast Battleships 1943–45

Battleship	Class	Commissioned	Deployed FCTF
BB-55 *North Carolina*	North Carolina	Apr 1941	Nov 1943
BB-56 *Washington*	North Carolina	May 1941	Nov 1943
BB-57 *South Dakota*	South Dakota	Mar 1942	Nov 1943
BB-58 *Indiana*	South Dakota	Apr 1942	Nov 1943
BB-59 *Massachusetts*	South Dakota	May 1942	Nov 1943
BB-60 *Alabama*	South Dakota	Aug 1942	Jan 1944
BB-61 *Iowa*	Iowa	Feb 1943	Jan 1944
BB-62 *New Jersey*	Iowa	May 1943	Jan 1944
BB-64 *Wisconsin*	Iowa	Apr 1944	Dec 1944
BB-63 *Missouri*	Iowa	June 1944	Jan 1945

A

TASK GROUP CRUISING FORMATION

"Cruising disposition 5-V" was tailored to maximize anti-aircraft defense, and was the Fast Carrier Task Groups' primary battle formation. Any rotation in fleet heading would take place around the center.

In the center of each Task Group, three to four heavy and light carriers (CV and CVL) were arranged evenly within a 2,000-yard radius circle **(Circle 2)**. Each carrier was allowed an operating circle of 1,500 yards around its station in which to maneuver independently. This allowed ample space for each carrier and air group to maneuver within the Task Group when the entire formation turned into the wind to launch a full strike.

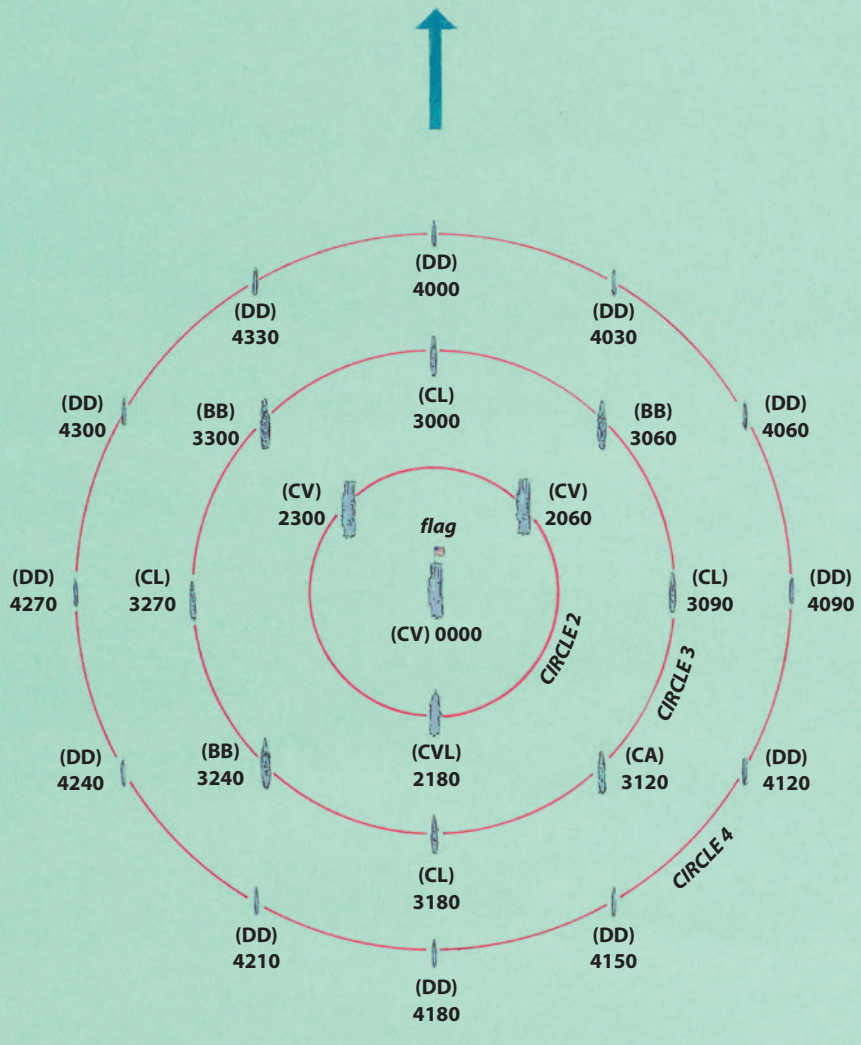
Immediately outward of the carriers were the battleships (BB) and heavy and light cruisers (CA and CL) in **Circle 3**, spaced to alternate battleship/cruiser – carrier – battleship/cruiser. Outside these was the destroyer screen (DD), arranged here in **Circle 4**. Destroyers maintained continuous echo-ranging watch over radar sectors as ordered by the Officer in Tactical Command. Finally, some 50 miles out in four directions, were the outer radar picket destroyers – here, "13," "14," "15," and "16."

Each ship in Disposition 5-V had its own four-digit station assignment, as overprinted here. The first digit was its designated circle (in thousands of yards from fleet center), and the last three digits its relative bearing from the fleet center (in degrees). Thus, the destroyer assigned to "4180" (here at 6 o'clock) is in Circle 4 (4,000 yards from fleet center), at a relative bearing of 180 degrees from the center.

When not in battle formation the Task Group's typical cruising formation was Disposition 5-R, in which the destroyers were 6,000 yards out instead of 4,000 yards.

(DD) 13

(DD) 14



(DD) 16

(DD) 15

The heavy cruiser USS *Baltimore* (CA-68), name ship of her class, cruises off Massachusetts during her shakedown on June 18, 1943. Five of the six wartime Baltimores served with the Fast Carrier Task Force. They were the only wartime US heavy cruisers not limited by prewar treaty conditions, and they largely functioned as fast carrier escorts. (Navsource)

The fast and versatile **destroyers** (**DD**) were employed as anti-aircraft screens, anti-submarine (ASW) platforms, radar pickets, and plane guards for the fast carriers. In the event of a surface action, some destroyers would have screened the carriers and battleships while others executed torpedo attacks. Arriving in 1942, the 35-knot, 2,325-ton Fletcher class was the ubiquitous war-built US destroyer and the standard screening ship for the FCTF, employing 5 single-mounted 5-inch/38 DP guns, 10x 21-inch Mark 15 torpedoes in two quintuple mounts, and several depth-charge racks and K-gun projectors for ASW work. The Fletchers were eventually augmented by two improved designs mounting 6x 5-inch/38 DP guns in three double turrets: the 34-knot, 2,200-ton Allen M. Sumner class, and the 37-knot, 2,616-ton Gearing class, introduced in 1943 and 1945 respectively.

Auxiliaries

Large numbers of often forgotten but vital auxiliaries sustained the Fast Carrier Task Force's relentless operational tempo, and included replenishment ships of all kinds. Most commonly accompanying the FCTF were high-speed fleet oilers (tankers) for underway replenishment, exemplified by the 18-knot, 24,830-ton Cimarron class, first commissioned in 1939. Mounting 4x 5-inch/38 DP guns for defensive purposes, the Cimarrons typically carried 80,000 barrels of fuel oil, 18,000 barrels of aviation gasoline, and 6,782 barrels of diesel oil.

ORGANIZATION

The wartime **United States Fleet** comprised the USN's major sea-going combat forces. Commanded by Adm Ernest J. King, it was divided between the Atlantic Fleet and the Pacific Fleet. The Atlantic and Pacific Fleets were geographically organized into numbered Fleet commands, with even-numbered Fleets in the Atlantic and odd-numbered Fleets in the Pacific.

Nicknamed "The Big Blue Fleet," the **Central Pacific Force** under Vice Adm Raymond Spruance was established within Adm Chester Nimitz's **United States Pacific Fleet** on August 5, 1943. Central Pacific Force would fully adopt its naval title **Fifth Fleet** on April 26, 1944. Fifth Fleet was tasked to execute War Plan Orange's long-planned Central Pacific offensive, which was expected to culminate in a decisive fleet action followed by a war-ending blockade of Japan.

Huge and self-contained, Fifth Fleet encompassed most of the US Pacific Fleet's front-line combat units, and consisted of three complementary forces: **Fast Carrier Task Force** (high-speed battle fleet); **Joint Expeditionary Force** (amphibious flotillas, amphibious air and fire support units, and embarked Marine and Army divisions); and **Defense Forces and Shore-Based Air** (prefabricated forward bases, Marine defense battalions, and land-based USN, USMC, and USAAF air units).

Adopted in April 1941, a USN **Task Force**, commanded by at least a rear admiral, was a flexible, impermanent tactical organization of any necessary size and configuration, to which forces were assigned for a specific mission. Task Forces could be organizationally subdivided as needed into **Task**

Groups, which were themselves divisible into smaller **Task Units**. Task Units could be divided into even smaller **Task Elements**. This fluid four-tier system gave the US Navy exceptional operational flexibility.

Confusingly, the FCTF bore many names and designations during 1943–1945, often simultaneously. The officially-titled **First Carrier Task Force** was established in mid-November 1943 and simultaneously designated **Task Force 50**. Vice Admiral Marc Mitscher assumed command on January 6, 1944, and the First Carrier Task Force/ Task Force 50 was then redesignated **Task Force 58**.

On August 26, 1944, Adm William "Bull" Halsey relieved Spruance in a planned "two-platoon" command system, whereupon Fifth Fleet adopted Halsey's pre-existing South Pacific command designation of Third Fleet. Simultaneously, Mitscher's First Carrier Task Force/Task Force 58 became the **Second Carrier Task Force/Task Force 38**. Mitscher retained nominal command of TF-38 until October 30, 1944, when he was relieved by Vice Adm John S. McCain. Spruance and Mitscher resumed command of Fifth Fleet and TF-58, respectively, on January 26, 1945, before Halsey and McCain once again relieved Spruance and Mitscher on May 27, 1945. Halsey and McCain would command Third Fleet and TF-38 until the end of the war in August 1945. At all times the terms refer to the same formations and crews – only the command staffs and nomenclature changed.

American naval power became so overwhelming that by mid-1944 plans were made to split the single "Big Blue Fleet" into *separated* Third and Fifth Fleets for Operation "Olympic," the anticipated November 1945 invasion of Kyushu. Halsey and Spruance would command at sea concurrently, with Halsey independently conducting offensive sweeps against Honshu, while Spruance conducted Kyushu's amphibious invasion. The Fast Carrier Task Force would likewise be split into the First and Second Carrier Task Forces again, simultaneously designated TF-58 and TF-38 respectively, of 13 fast carriers each. Japan's surrender in August 1945 canceled these plans.

US Fast Carrier Task Force Strength 1943–45

Operation	Date	Fleet	Cmdr	Task Force	Cmdr	TGs	CV (CV+CVL)	CV aircraft	BB	CA (CA+CB)	CL (CL + CLAA)	DD
Gilberts	Nov 1943	Fifth	Spruance	TF-50	Pownall	4	11 (6+5)	703	5	3 (3+0)	3 (0 + 3)	21
Truk	Feb 1944	Fifth	Spruance	TF-58	Mitscher	3	10 (5+5)	579	6	5 (5+0)	5 (3+2)	29
Marianas	June 1944	Fifth	Spruance	TF-58	Mitscher	5	15 (6+9)	896	7	8 (8+0)	13 (9+4)	58
Leyte Gulf	Oct 1944	Third	Halsey	TF-38	Mitscher	4	17 (9+8)	1,074	6	6 (6+0)	9 (6+3)	58
Okinawa	Mar 1945	Fifth	Spruance	TF-58	Mitscher	4	17 (9+8)	1,213	8	7 (5+2)	15 (10+5)	86
Japan*	July 1945	Third	Halsey	TF-38	McCain	3	16 (10+6)	1,150	8	4 (4+0)	15 (10+5)	64
Japan**	July 1945	Third	Halsey	TF-38 + TG-37.1	McCain + Vian	4	20 (14+6)	1,404	9	4 (4+0)	21 (13+8)	81

* USN forces only

** included British Royal Navy's TG-37.1, cmdr Adm Sir Philip Vian

Command

The Fast Carrier Task Force's 1940s-era technology of steam-powered machinery, mechanical computers, and vacuum tube electronics was extremely manpower-intensive. Departing Majuro on June 6, 1944, Mitscher's TF-58 comprised 15 fast carriers, seven fast battleships, 21 cruisers, 58 destroyers, 891 aircraft, and 96,618 personnel – enough to man seven US infantry

Broadside view of the Fletcher-class destroyer USS *Cotten* (DD-669), assigned to TF-58 in January 1944. Her five 5-inch/38 DP guns in single turrets are apparent. Designed for long range, the Fletchers quickly became the Fast Carrier Task Force's workhorse; their contribution, often serving in the perilous radar picket role, receives less attention than it deserves. (Navsource)

The Fast Carrier Task Force was entirely dependent upon the US Navy's vast investment, and competence, in mobile logistics. Here the oiler USS *Cimarron* (AO-22) is photographed while steaming alongside USS *Yorktown* (CV-10), March 4, 1945. An oiler dispensed fuel oil from four stations on the well deck, two on each side. Cargo winches supporting the heavy hoses were mounted on the spar decks above the well deck, allowing fuel details to work above the turbulent Pacific swells. US warships ran on Bunker C (Number 6) fuel oil, a high-viscosity, heavy distillate residual oil obtained after light and medium distillates such as gasoline, diesel, and kerosene were refined out. The thick Bunker C oil required pre-heating to 219–261 degrees F to burn or transfer. (Navsource)

divisions (or almost 24,000 more Americans than were landing that day in Normandy). Individual carriers, battleships, and cruisers were commanded by captains. Destroyers and oilers were skippered by commanders, or even lieutenant commanders with as little as five years' active service.

Congressional legislation on June 24, 1924 had required all aircraft carriers, naval air units, and naval air bases to be commanded by qualified aviators. This far-sighted and uniquely American requirement proved invaluable during World War II. With naval aviation in its infancy, qualified senior officers were lacking, prompting a temporary aviation "observer" course that senior officers could undertake to fulfill the Congressional requirement. A few, such as Adms Halsey and King, earned their full pilot wings.

Inevitably, the cultures and career progression of naval aviators and other line officers diverged. The disruptive, revolutionary nature of aviation attracted irreverent, outspoken personalities, producing a self-reinforcing culture distinct from the parochial, battleship-dominated "Gun Club." A trivial but immediate sign of this was that instead of the black shoes worn by the rest of the Navy, USN aviators had adopted brown shoes from their USMC aviator brethren in World War I. Aviators and non-aviators were inevitably nicknamed "brown shoes" and "black shoes" respectively, reinforcing the idea of separate cultures. Additionally, a second cultural tension existed within the naval aviation community between career aviators and "Johnny-come-lately" graduates of the senior officer course.

Non-aviators had often commanded carrier task forces through 1942, though aviators complained that such officers did not know how to conduct carrier operations effectively. Naval aviation's unofficial godfather was long-time aviator Vice Adm John H. Towers, commander Air Force, Pacific Fleet and Nimitz's Pacific Fleet deputy commander. Regarding the FCTF, on August 21, 1943 Towers proclaimed: "On the degree of skill and imagination with which this powerful force is employed may depend the difference between a reasonably expeditious victory in the Pacific and a long drawn out war … Carrier air operations are highly specialized and

should be conducted by officers thoroughly trained therein. To be 'air-minded' is no substitute for long aviation experience."

By summer 1944, successful fast carrier captains were often rewarded with command of an escort carrier division before being promoted to lead a fast carrier division (Task Group). Rear admirals tapped to command a carrier Task Group rode along as observers for months before assuming command; this on-the-job training was nicknamed "makee-learn" (make you learn) status.

By wartime operational necessity, aviator admirals began eclipsing battleship admirals. King decreed that carrier admirals exercise tactical command of fast carrier Task Groups regardless of seniority – an extraordinary break with naval tradition, as the surface officers commanding the carriers' screens were usually senior to the younger carrier admirals. In January 1944 King ordered that all non-aviator commanders have aviator chiefs of staff, and all aviator commanders have non-aviator chiefs of staff. This initially unpopular directive broke up old cliques and infused USN staffs with intellectual freshness. Meanwhile the wartime USN was rapidly becoming an "air navy"; of the 30 USN captains promoted to flag rank between October 1943 and August 1945, 19 were aviators.

AIR GROUP EQUIPMENT & ORGANIZATION

Carrier aviation demanded rugged, specialized aircraft. Airframes and undercarriages required increased resistance to saltwater corrosion, and extra strengthening to absorb hard carrier landings – which were actually controlled stalls, violently arrested by wires and barricades. US carrier aircraft were powered by air-cooled radial engines, which were preferred for their ruggedness, simpler maintenance, and shorter nose that gave better visibility for gunnery and landing. However, the radial engines' larger frontal cross-section imposed greater drag than comparable liquid-cooled inline engines.

In 1941 the USN adopted cockpit armor, and self-sealing wing fuel tanks which were internally lined with layers of natural and synthetic rubber. When punctured by enemy bullets the rubber lining swelled and sealed the hole, saving fuel and reducing fire risk. The extra weight degraded performance compared to Japanese aircraft lacking these features, but the increased survival rate of US aircrew – who frequently lived to learn, and eventually teach, from their mistakes – initiated a virtuous cycle in American aircrew quality versus their Japanese counterparts which arguably proved decisive.

US carriers opened the 1942 carrier battles armed with the obsolescent F4F Wildcat fighter, SBD Dauntless dive-bomber, and TBD Devastator torpedo-bomber. By late 1943 these types had been almost entirely replaced by a brand-new generation of aircraft far superior in performance and war load, the key improvement being far more powerful engines. The Wildcat's, Dauntless's, and Devastator's various powerplants together had averaged 1,033 horsepower; the succeeding Hellcats, Corsairs, Helldivers, and Avengers almost doubled this at 1,962 horsepower.

Radio communication between aircraft was to be brief, essential, and spoken clearly and decisively using standard phraseology. Non-radio

Two Grumman F6F-3 Hellcats in tricolor camouflage, and the red-outlined insignia ordered briefly in spring-summer 1943. Grumman claimed its Hellcat was designed to be flown by "200-hour farmboys," and built 11,000 of them in just two years. Its high performance, heavy firepower, easy handling, and rugged construction made it the standard US carrier fighter from late 1943 until the end of the war. Grumman rolled out the 12,275th and final Hellcat in November 1945. (Wikimedia)

communication was preferred whenever possible. By late 1943 US carrier aircraft generally employed the 25-watt AN/ARC-5 radio, capable of plane-to-plane and plane-to-ship voice communication through four-channel VHF-AM radiotelephone, as well as Morse code. Following the AN/ARC-5 was the 8-watt, ten-channel VHF AN/ARC-1. Avengers and Helldivers were also equipped with an additional 100-watt, ten-channel AN/ART-13. VHF/UHF communications were fairly reliable to 100nm, the range increasing with altitude.

Fighters

By late 1943 the excellent Grumman F6F Hellcat had become the standard US fast carrier fighter. While far more rugged than the A6M Zero, at

B

FLIGHT DECK CYCLES

(1) Launch cycle

This image is painted to include the basic flight deck marking (here CV-9, USS *Essex*), and the launching path of an F6F Hellcat (broken blue arrow) in the "Fly One" area. Aircraft were parked in "Fly Three" on the stern – armed, fueled, and ready to fly. Here we represent the last two Hellcats of this launch, ready with wings deployed; behind them with wings folded are 11 SB2C Helldivers; finally two TBM Avengers have wings deployed, and 12 more are still folded. (Squadron combat strength might vary due to rates of serviceability.)

Brown-shirted plane captains ran up aircraft engines while pilots were still in the ready rooms. The flag lieutenant called out, "Execute the signal!" and the carrier turned into the wind (actually, slightly to starboard of it, so the wind would blow smoke from the "island" away from the flight deck) and cruised at speed. The red-and-white "Fox" flag was raised on the yard to signal that flight operations were underway. On the order "Pilots, man your planes!" aircrew boarded their aircraft and strapped in. A firing mechanism in each cockpit detonated a small explosive charge inserted into the planes' engine, turning it over. Yellow-shirted flight deck directors guided the planes one at a time to their take-off position. The yellow-shirted Flight Deck Officer took position off the first plane's right wingtip. He then directed each pilot to rev up his engine to half-power, then full-power, by showing first one and then two fingers of his left hand. With his right hand he then rotated a checkered flag down and pointing towards the ship's bow. The pilot released his brakes and launched down the flight deck, with his canopy open (in hope of escaping quickly from a crash.)

(2) Landing cycle

This schematic image indicates the two seldom-used hydraulic catapults (green); the three plane elevators connecting to the hangar deck (gray); the catwalks flanking the edges of the flight deck (yellow); the gun turrets and positions (black outlines); the crash barricade and arrestor wires (red); the Landing Signals Officer's platform near the stern in the port catwalk (pink); and the paths of a landing F6F (broken blue arrow), and a previously landed plane being manhandled forward (solid blue arrow.)

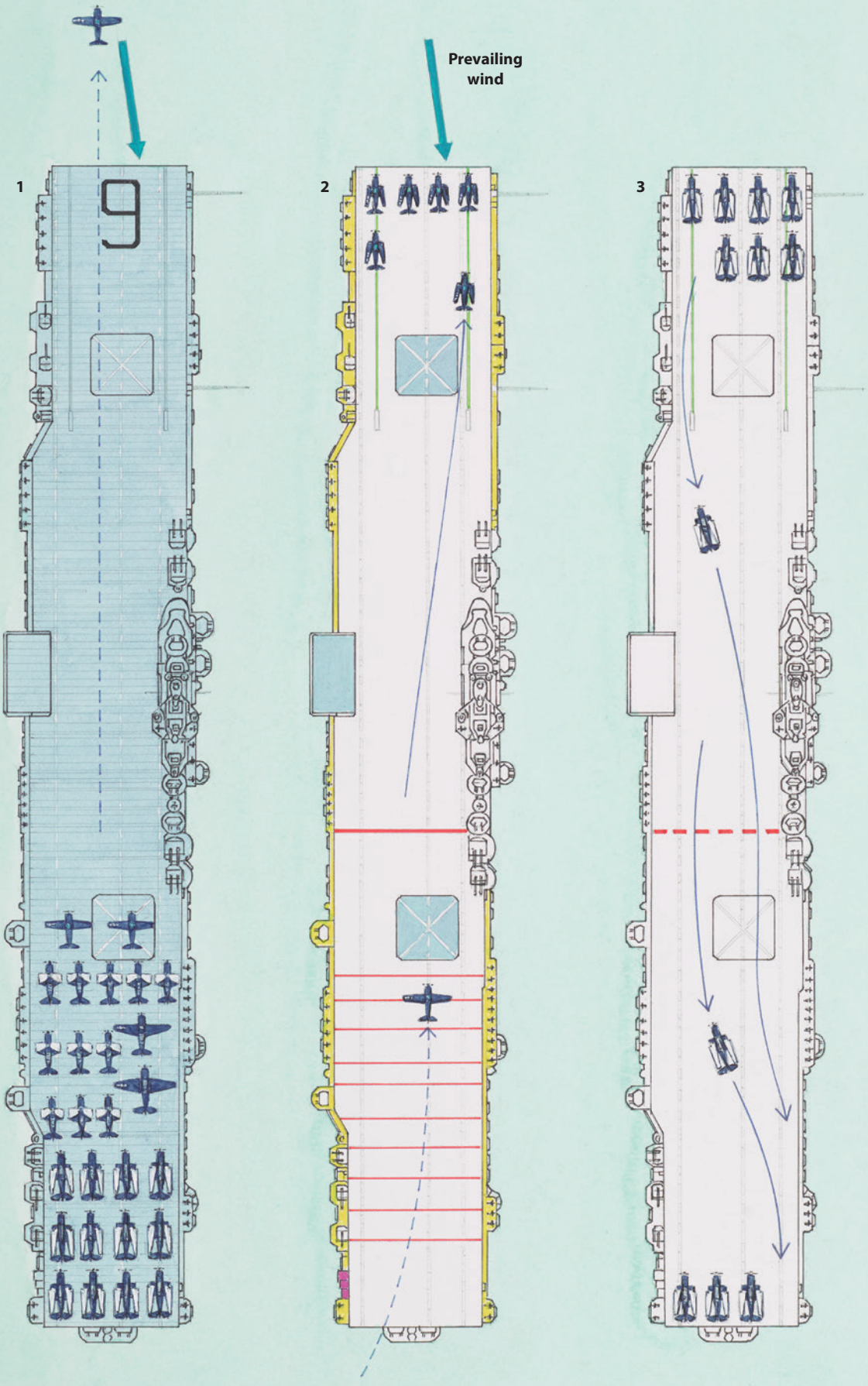
The order "Stand by to receive aircraft!" commenced landing operations. Plane captains of airborne planes, handling crews, chock-men, and wing-folders all manned stations in the forward catwalks. Crash equipment was readied by the island and/or on catwalks: a crash dolly, hydraulic jack, wheel dolly, block and tackle, and plenty of line. Crash barricades and arrestor gear were raised. Hook-release men and plane directors made ready. The carrier signaled that it was turning into the wind, and a plane-guard destroyer took station astern. A green flag for landing operations was raised on the island, and just beneath it the speed of the wind over the deck was posted in knots. When all crew were ready, the planes received the signal to land on the completely clear deck.

Fighters typically landed first because they had fewer accidents. Each was visually checked during approach – "Hook [is] down, wheels down, flaps down." The signal "Deck clear" was given. The LSO issued instructions to the pilot via signals; upon a satisfactory approach the LSO signaled "Cut!" The pilot cut his engine and the plane stalled to a landing on the deck, catching arrestor wires. Hook-release men ran out to release the tailhook from the wire. The plane director signaled "Hook [is] up!" and "Fold flaps!" and then passed the fighter up the deck to the next director. The crash barricade was dropped, and 8–10 plane-pushers would manhandle the aircraft over the lowered barricade to the very prow of the flight deck, port side first, wings folded, left wing first. Once parked, a plane's wheels were chocked, and it was tied down with line and electrical "ground" connectors to cleats inset in the flight deck. It was then immediately refueled and re-armed, and plane captains fixed a restraint to the cockpit controls to keep the control surfaces from flapping in high wind.

Once the barricade was re-erected and deck arrestor gear reset, the next plane would land, not waiting for the previous plane to be fully parked. The second plane to land would be pushed to the starboard corner of the bow; planes were parked in sequence from outside to inside, so refueling and re-arming could begin immediately. If multiple returning strikes were expected, the landed planes could instead be pushed forward only as far as the bow elevator, and lowered into the hangar.

(3) Re-spotting for launch

On this schematic refueled and re-armed TBM Avengers are being towed from bow to stern through the "Fly Two" midships area, to be ready for the next launch. After landing, planes could be parked up to five abreast on an Essex class carrier.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2
Prevailing wind
3

An F4U Corsair rockets Japanese positions on Okinawa, 1945. The Corsair had been the first US single-engined fighter to exceed 400mph, on October 1, 1940. Logistic inertia meant that wartime Corsairs were largely assigned to the Marines, but by early 1945 both USMC and USN Corsair squadrons had begun deploying on US fast carriers in strength, and were taking over the role of the embarked dive-bombers to a significant extent. The Corsair was more accurate, could fly more missions per day, and three could fit in the deck space taken up by every two Helldivers. (US Naval Aviation Museum)

392mph the F6F-5 Hellcat also outperformed the Japanese fighter in all but low-speed maneuverability. Hellcats ultimately produced 305 USN/USMC aces and claimed 5,163 kills against 270 total air-to-air losses, including a 13:1 kill ratio against the Zero. The USN's all-time leading ace Cdr David McCampbell (34 kills) recalled the Hellcat as "an outstanding fighter plane. It performed well, was easy to fly, and was a stable gun platform. But what I really remember most was that it was rugged and easy to maintain."

Designed in 1940, the powerful and highly-anticipated Vought F4U Corsair was hampered by technical issues. A much "hotter ship" than the Hellcat, the Corsair was deemed unsafe for carrier use; in 1943 it was relegated to land bases and USMC squadrons, where it demonstrated exceptional combat performance. The British Royal Navy led technical and doctrinal improvements which largely solved the Corsair's carrier issues. The F4U-1 qualified for US carrier operations in April 1944, and the F4U-4 that began joining USN squadrons in October 1944 had a top speed of 446mph. By February 1945, USN and USMC Corsairs comprised 25 percent of the fast carriers' fighter strength.

Both the Hellcat and Corsair were armed with 6x M2/M3 Browning .50-caliber machine guns, the primary USN fighter armament through 1945. Between 1943 and 1945 the M2's firing rate was increased from 850 to 1,200 rounds per minute. When combined with the new Stellite barrel liner,

On the crowded flight deck of USS *Lexington* (CV-16), F6F-3 Hellcats and SBD-5 Dauntlesses prepare to strike New Guinea, April 1944. A yellow-shirted plane director directs traffic, while blue-shirted plane handlers pull chocks free. Deck personnel knew to avoid whirling propeller blades by staying outside the landing gear, which was the same width as the propeller. (Navsource)

the resulting M2 was designated the M3. By late in the war, some fighters' .50-cal M2/M3s were being replaced by the more lethal Hispano-Suiza AN-M2/M3 20mm cannon. The Hellcat and Corsair were a quantum leap over existing Pacific War fighters; no mass-produced Japanese type ever matched them in air-to-air combat, and they additionally proved excellent fighter-bombers. Their superb performance was due to Pratt & Whitney's 2,000hp R-2800 Double Wasp 18-cylinder radial engine.

US Fast Carrier Aircraft. 1943–45

	Grumman F6F-3 Hellcat	Vought F4U-1D Corsair	Douglas SBD-3 Dauntless	Curtiss SB2C-4 Helldiver	Grumman TBF-1C Avenger
Type	Fighter-bomber	Fighter-bomber	Scout/Dive-bomber	Dive-bomber	Torpedo- bomber
Length	33ft 7in	33ft 4in	32ft 8in	36ft 8in	40ft 0in
Span	42ft 10in	41ft 0in	41ft 6in	49ft 9in	54ft 2in
Height	13ft 1in	16ft 1in	13ft 7in	13ft 2in	16ft 5in
Loaded weight	12,441lbs	12,039lbs	9,407lbs	14,189lbs	16,412lbs
Engine	R-2800-10W	R-2800-8W	R-1820-52	R-2600-20	R-2600-8
Horsepower	2,000hp	2,250hp	1,000hp	1,900hp	1,700hp
Max speed/at altitude	375mph/ 17,300ft	425mph/ 20,000ft	250mph/ 16,000ft	295mph/ 16,700ft	257mph/ 12,000ft
Cruising speed	160mph	182mph	152mph	158mph	153mph
Climb rate	3,500ft/min	3,120ft/min	1,190ft/min	1,800ft/min	1,410ft/min
Service ceiling	37,300ft	36,900ft	27,100ft	29,100ft	21,400ft
Range/with bombload	1,090nm/ 0lbs	500nm/ 2,000lbs	1,345nm/ 1,000lbs	1,165nm/ 1,000lbs	1,105nm/ Torpedo
Fixed guns	6 x 0.50	6 x 0.50	2 x 0.50	2 x 20mm	2 x 0.50
Flexible guns	-	-	2 x 0.30	2 x 0.30	1 x 0.50 + 1 x 0.30
Bombload	1,000lbs	2,000lbs	1,200lbs	2,000lbs	2,000lbs

Scout/Dive-bombers

Dive-bombing, a 1926 USN innovation, had made carrier aircraft accurate enough to hit moving ships. In 1942 the Douglas SBD Dauntless was the carriers' most effective weapon; its reliability and forgiving flight characteristics made it a favorite with aircrew, but by 1943 its performance was outdated, and another major drawback was its lack of folding wings. However, pilot affection and problems with the new Helldiver meant that the Dauntless was not phased out of fast-carrier operations until July 1944.

The SBD's designated replacement was the Curtiss SB2C Helldiver, which arrived in 1943 wracked with mechanical flaws and technical defects. Power and low-speed handling were particularly deficient. Factory quality-control was an issue, but the Helldiver's problems were partly due to vacillating USN requirements, including 880 requested changes which caused a series of cascading technical and performance issues. By 1945 the SB2C-4 had mitigated many of the early Helldiver's faults, and Helldivers would ultimately sink more Japanese tonnage than any other aircraft.

Torpedo-bombers

The primary mission of torpedo-bombers was sinking enemy carriers and battleships. Coming online in June 1942, the Grumman TBF Avenger

1943: in the hangar of USS *Yorktown* (CV-10), while some off-duty crew in the background watch a movie, Carrier Air Service Division personnel work on F6F-3 Hellcats. The average USN carrier aircraft's radial engine was made up of 14,000 parts, and it needed to be completely disassembled and rebuilt, if not replaced, every 500–600 flight hours. (Navsource)

was large enough to carry its torpedo in an internal bomb bay. In addition to two fixed forward-firing .50-cal M2/M3 machine guns, Avengers sported a dorsal turret mounting an additional .50-cal, as well as a ventral "stinger" Browning M1919 .30-cal machine gun, that were flexible (individually aimable). Range when carrying a torpedo was 1,105nm, top speed was 257mph at 12,000ft, and standard cruising speed 153mph. The Avenger's size made it adaptable to many missions and configurations, such as an airborne radar platform and a VIP transport. Most Avengers were built under license by General Motors as the TBM Avenger. By 1945 Avengers were largely used to drop bombs, since Japan had little left for them to torpedo.

Floatplanes

Float-equipped observation planes were embarked by all battleships and cruisers except the Atlanta-Oakland class. TF-58 embarked 57 floatplanes by June 1944. Originally intended for shell-spotting, floatplanes were used for many auxiliary purposes. With their ability to operate from water, they were invaluable in rescuing downed airmen, often under enemy fire. Floatplanes could also scout up to 270nm out. The USN started the war with the 165mph Curtiss SOC Seagull, but by late 1943 the standard floatplane was the 164mph Vought OS2U Kingfisher. By 1945 the Kingfisher was augmented by the 313mph Curtiss SC Seahawk.

Groups

Pacific-assigned carriers and their aircraft were administratively part of Air Force, Pacific Fleet. A carrier's assigned air complement was its **Carrier Air Group** (**CAG**). In 1941 a CAG was permanently assigned to and named after its carrier (e.g., Enterprise Air Group), but by 1942 they were redesignated according to their parent carrier's hull number (e.g., CVG-6). However, this numerical coordination system quickly disappeared; unlike their IJN counterparts, American CAGs were interchangeable, and not administratively tied to the carriers that hosted them. By June 1944, the CAGs of large carriers were redesignated **CVG** and led by a commander, and those of light carriers **CVLG** and led by a lieutenant commander.

Squadrons

Each CAG was composed of multiple squadrons by type: fighter (**VF**), dive-bomber (**VB**), scout-bomber (**VS**), torpedo-bomber (**VT**), and eventually fighter-bomber (**VBF**). The squadron was the smallest administrative air unit, and typically led by a lieutenant commander. A squadron comprised at least two **divisions**, described as "the optimum tactical unit of a squadron" and consisting of 4–6 planes each. A division was divided into 2–3 **sections**, the "basic tactical unit of a formation." A section usually comprised two fighters or three bombers, and was commanded not by the highest-ranking aviator but by the most experienced.

The composition of a standard 1941 CAG of 72–73 aircraft had been one VF squadron (18 fighters), one VB squadron (18 dive-bombers), one VS

A partial cross-section of flight deck crew in a 1941 prewar photo taken aboard USS *Enterprise* (CV-6); the flight deck is noticeably painted in highly visible prewar colors. Visible are "airdales" wearing red shirts (fuelers), green (catapult and arresting gear crew), blue (on-deck plane pushers), and yellow (plane directors), along with enlisted denim dungarees. In 1943–45 other colors worn were blue with a white H (hangar pushers), brown (plane captains), white with red cap (ordnance), and white with red cross (medical); emergency aircrew extraction teams wore white fire-proof asbestos suits. (Getty Images)

squadron (18 scout-bombers), and one VT squadron (18 torpedo-bombers). The VB and VS squadrons were cross-trained and essentially interchangeable. The CAG commander typically flew his own bomber; because he was promoted from a squadron command, he was sometimes a career fighter pilot new to bombers.

Wartime CAG size and composition evolved greatly due to changing conditions and combat experience. Widespread introduction of folding-wing aircraft allowed larger CAGs, which tended towards adding more fighters. In 1943, Essex-class carriers carried a 90-plane CAG comprising 36 Hellcat fighters, 36 Dauntless or Helldiver dive-bombers, and 18 Avenger torpedo-bombers. The VS squadron was eliminated in November 1943, as scouting was taken over by radar-equipped Avengers. By November 1944 the CVG had evolved to 96 aircraft: 54 Hellcats, 24 Helldivers, and 18 Avengers. Additionally, Hellcats were developed into fighter-bombers capable of dropping 500lb bombs, and all bomber pilots were fighter-qualified.

By early 1945, CVG make-up had evolved to 103 aircraft: 73 fighters (Hellcats and Corsairs), 15 Helldiver dive-bombers, and 15 Avenger torpedo-bombers. In January 1945 *Essex* and *Wasp* experimented with 91 fighters and 15 torpedo-bombers. That same month the unwieldy 73-plane, 110-pilot fighter squadron was split into a 36-plane fighter squadron (VF) and a 36-plane fighter-bomber squadron (VBF). As a late-war example, the Essex-class carrier USS *Bennington* (CV-20) reported 103 aircraft in June 1945, including a filled hangar capacity of 51 (36 Corsairs and 15 Helldivers), with 52 aircraft parked on deck. The following month a new CVG makeup of 101 aircraft was authorized: 32 fighters (24 day fighters, 4 photo-recon fighters, 4 night fighters); 24 fighter-bombers; 24 Helldivers; and 20 Avengers, plus the CAG commander in his own fighter.

The Independence-class light carriers originally operated up to 47 aircraft, but by early 1944 the CVLG had been standardized at 33, comprising 24 Hellcats and 9 Avengers. Throughout the war Adm King resisted numerous recommendations that the Independences be converted to all-fighter carriers. Finally, in July 1945, an all-interceptor CVLG of

LtCdr Paul Buie briefs his "Fighting 16" (VF-16) pilots aboard USS *Lexington* during the November -December 1943 Gilbert Islands operation. Self-discipline and selfless teamwork were absolutely vital to the success of a fighter squadron, and the USN's emphasis on fighter teamwork far exceeded that of their Japanese counterparts. (Navsource)

36 F4U Corsairs was authorized, to be replaced by 48 of the anticipated F8F Bearcats as soon as possible. However, the war ended before either the all-fighter CVLG or the F8F Bearcat saw action.

Shipboard & shore-based personnel

Maintaining CAGs aboard fast carriers were **Carrier Air Service Divisions (CASDiv)** of 533 men (17 officers, 516 enlisted). Unlike CAGs, CASDivs were permanently assigned to their carriers. The CASDiv's shore-based counterpart was the identical **Carrier Air Service Unit (CASU)**. In October 1944 forward-based CASUs were re-designated **Combat Aircraft Service Units (Forward)**, or **CASU (F)**. These were attached to standardized, prefabricated advanced naval airbases codenamed "Acorns" (42 officers, 770 enlisted). Each Acorn was constructed by a Naval Construction ("Seabee") Battalion of 1,115 men (33 officers, 1,082 enlisted). A total of 19 CASUs (F) and 17 Acorns were ultimately established in the Central Pacific, the fast carriers' prime operating area.

Aviators

Between 1942 and 1945 the USN produced a total of 61,658 pilots. USN pilots were overwhelmingly junior officers with college credit, while radiomen/gunners were aviation ratings. By 1944 total pilot training lasted 16 months, of which the final 9–10 months was flight training. Newly-commissioned aviators gained their carrier qualification aboard the auxiliary training carriers USS *Sable*, *Wolverine*, or *Charger,* and were then assigned to squadrons. By summer 1944, new CAGs qualified at San Diego or Hawaii aboard escort carriers, USS *Ranger*, or fast carriers that were working-up there, before transferring to an advanced Pacific base to join their assigned front-line carrier. By February 1945 the average US carrier pilot had logged 525 hours' flight time before his first combat assignment. By comparison, his

IJN counterpart had flown just 275 hours by December 1944, and a mere 100 hours by July 1945.

In early 1944, to ensure sufficient combat/stateside rotation, Adm Nimitz directed that a ratio of 1.67 CAGs be established for every commissioned carrier. Initial 1944 USN pilot production was slated for 20,000, but this was overconfidently slashed to 6,000 on June 4, 1944, precipitating a late 1944 crisis as the grueling Philippines campaign inflicted unforeseen pilot combat fatigue. CAG tours of duty, previously six to nine months, were accordingly reduced to six months and sometimes four. In December 1944 the unanticipated shortage of USN aviators compelled the Navy to authorize ten USMC fighter squadrons (18 Corsairs each) to deploy to the fast carriers. The 1.67 CAGs-per-carrier ratio was increased to 2.0 CAGs per carrier, and pilot production was re-increased to 8,000 annually.

OPERATIONS & TACTICS

Doctrine: prewar development, 1922–1941

The USN's first aircraft carrier was the purely experimental 15.5-knot, 12,700-ton USS *Langley* (CV-1), converted from the collier USS *Jupiter* and recommissioned on March 20, 1922. Prewar fleets had traditionally cruised in rectangular formations, to facilitate deploying into a single battle line. As early as 1923, however, a certain Cdr Chester Nimitz insisted on experimenting with *Langley* integrated into a circular formation. With radar not yet invented, station-keeping was tedious by day and impossible at night, but the circular formation proved excellent for maneuver and mutual anti-aircraft and anti-submarine coverage. By 1926 Nimitz was transferred to staff duty, and the circular formation was virtually forgotten until 1941.

Carrier operations are dictated by the speed and efficiency of their launch and landing cycles. By April 1928 the methodical Capt Joseph Reeves had driven *Langley*'s operational air group up from 6 to 42 aircraft. Among Reeves' innovations were the deck park, crash barriers, and specialized deck crews wearing football-inspired color-coded jerseys. In the 1929 Fleet Problem exercise, the converted 34-knot battlecruiser *Saratoga* raced ahead of her 23-knot battleships overnight and, using Reeves' operational methods, successfully hit the "enemy" Panama Canal with an 83-plane mock strike at dawn. Though *Saratoga* was later ruled sunk, the American concept of big, coordinated air strikes by large, fast carriers had been introduced, and would be further refined during the 1930s Fleet Problems.

Despite postwar myths, the unique value of aircraft carriers was widely appreciated

The light carrier USS *Cowpens* (CVL-25) underway on July 17, 1943. F6F-3 Hellcats are parked four-across on the narrow bow of the flight deck. Aviators assigned to light carriers took pride in the greater skills required to land on the smaller flight decks. The class's lead ship *Independence* (CVL-22) briefly mounted one 5-inch/38 gun on her bow; this was quickly replaced with a 40mm quad mount, making the Independence class the only Fast Carrier Task Force vessels without a 5-in/38 battery. (Navsource)

throughout the USN well before Pearl Harbor; the true interwar controversy was establishing their proper role within the US fleet. Battleship-trained officers believed that the battle line was the fleet's decisive element. The carriers' mission was to find the enemy so the battle line could engage it; thereafter the carriers would support the battleship action by air support and shell-spotting, while denying such missions to the enemy. Conversely, aviators saw carriers as fast and powerful offensive weapons, ranging independently of the battleships; wargames demonstrated that tying carriers to the battle line rendered them highly vulnerable. By the late 1930s all agreed that carriers' overriding tactical priority was the immediate destruction of the opposing fleet's carriers, thereby establishing air supremacy and effectively blinding the enemy for the duration of the battle.

Throughout the 1930s battleships remained largely invulnerable to contemporary carrier aircraft; biplanes simply lacked the power to carry sufficiently heavy armor-piercing ordnance. But as even light bombs put flimsy, unarmored carrier decks out of action, the Fleet Problems revealed that opposing carriers inevitably fought their own private war, in which whoever got sighted first was likely to be destroyed. After the 1930 Fleet Problem, Rear Adm Henry Butler noted that "Carriers are like two blindfolded men armed with daggers in a ring – there is apt to be sudden destruction to one or both." The USN accordingly devoted an entire squadron in each CAG to scouting; by 1941 Dauntless scouts even carried a 500lb bomb in the hopes of single-handedly knocking out an enemy flight deck as soon as it was discovered, since forming a properly-coordinated strike consumed precious time.

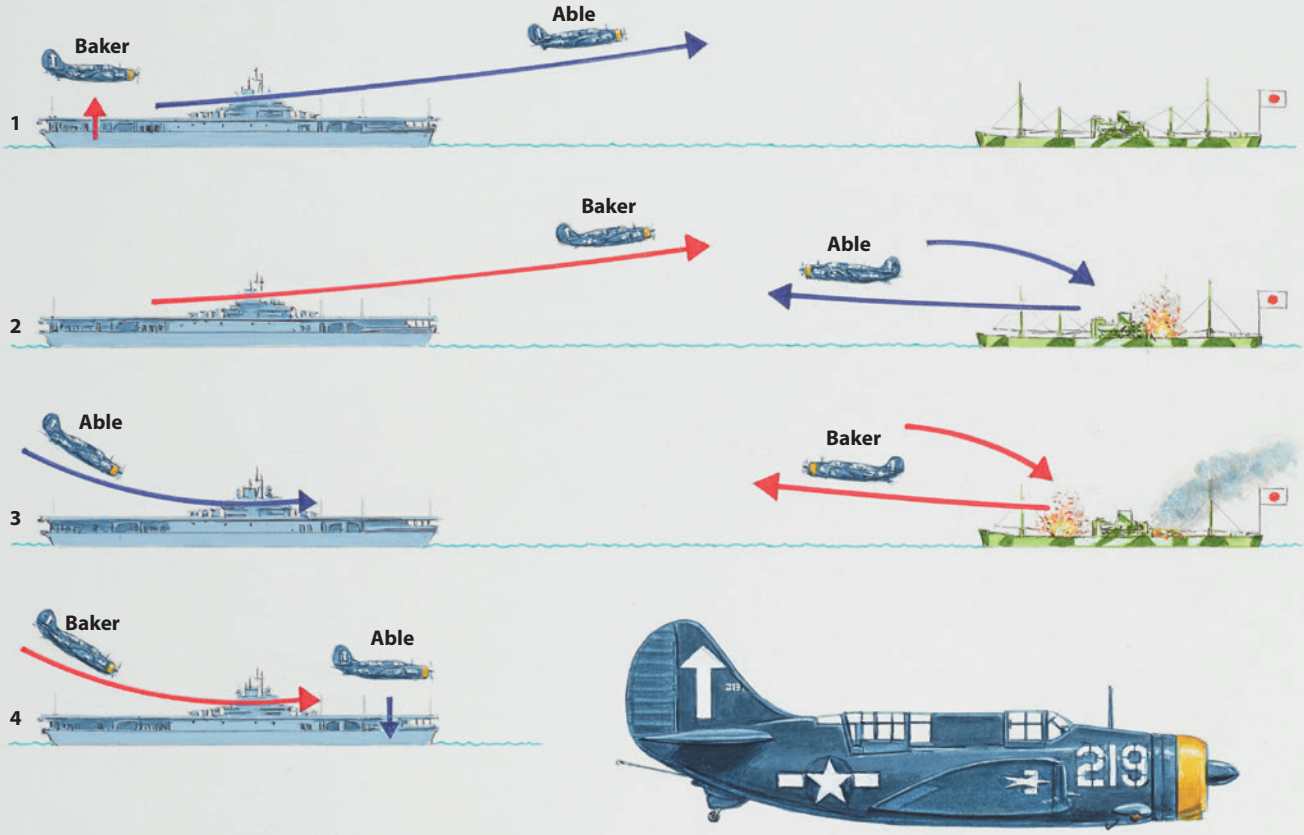
C

CARRIER STRIKE TACTICS

(Top) Two-strike cycle
Fast carrier groups usually employed the two-strike cycle, represented by this schematic of a strike on Japanese merchant shipping.
(1) "Strike Able" (blue) would be spotted entirely on deck, already fueled and armed, while "Strike Baker" (red) fueled and armed in the hangar below. As soon as Able was completely launched, elevators began bringing Baker up on deck.
(2) Once Baker was entirely spotted on deck, it would launch.
(3) With Baker away, the now-returning Able was recovered.
(4) Able was then re-struck below to be refueled and rearmed, clearing the deck for the recovery of the returning Baker. Once recovered, Baker would remain on deck to be refueled and rearmed for the next operational cycle. Continuous strikes could be maintained by re-arming and refueling returned strikes on deck and immediately re-launching them.
(Inset) SB2C-4 Helldiver of VB-84, embarked on USS *Bunker Hill* (CV-17), February 1945.

(Bottom) High-speed run-in
This tactic had been developed in the 1930s, to attack hostile airbases under cover of darkness. It was first employed during the February 1, 1942 Marshalls-Gilberts raids, and remained standard doctrine through 1945.
(1) The day before a strike, an oiler topped off the entire carrier Task Group in a position 200–300 miles from the target.
(2) Leaving the oiler behind, the Task Group then made an overnight 8- to 10-hour dash at 25 knots until 70 miles from the target; high speed and exact timing were crucial. The CAGs' launch was timed to hit the enemy airbase as dawn broke, so the dive-bombers could catch aircraft on the ground while the fighters established temporary air supremacy.
(3) US battleships and cruisers might detach from the Task Group to shell the enemy base under carrier air cover.
(4) The Task Group then recovered its CAGs, and at evening speedily retired out of range, protected by the cover of night while heading for its rendezvous with the oiler **(5)**.

The run-in and subsequent air strikes required moral fortitude on the part of a carrier commander. Deep in enemy territory, the Task Group's only defense against immediate counter-attack was to stand close offshore, pounding the enemy airbase until it was certainly (albeit temporarily) neutralized. When striking Kwajalein on December 4, 1943, TF-50 commander Rear Adm Charles Pownall withdrew prematurely, despite multiple reports of undamaged Japanese bombers remaining. The skipper of the *Yorktown* (CV-10), Capt "Jocko" Clark, angrily criticized Pownall's decision: "Goddammit, you can't run away from airplanes with ships!" The retreating TF-50 was subjected to hours of intense night-time torpedo-bomber attacks until the moon set the following morning, including a torpedo strike on the *Lexington* (CV-16). However, by mid-1944, TF-58 was powerful enough to stand offshore and hammer Japanese island bases indefinitely, although individual Task Groups were regularly detached on pre-emptive raids to screen TF-58's flanks.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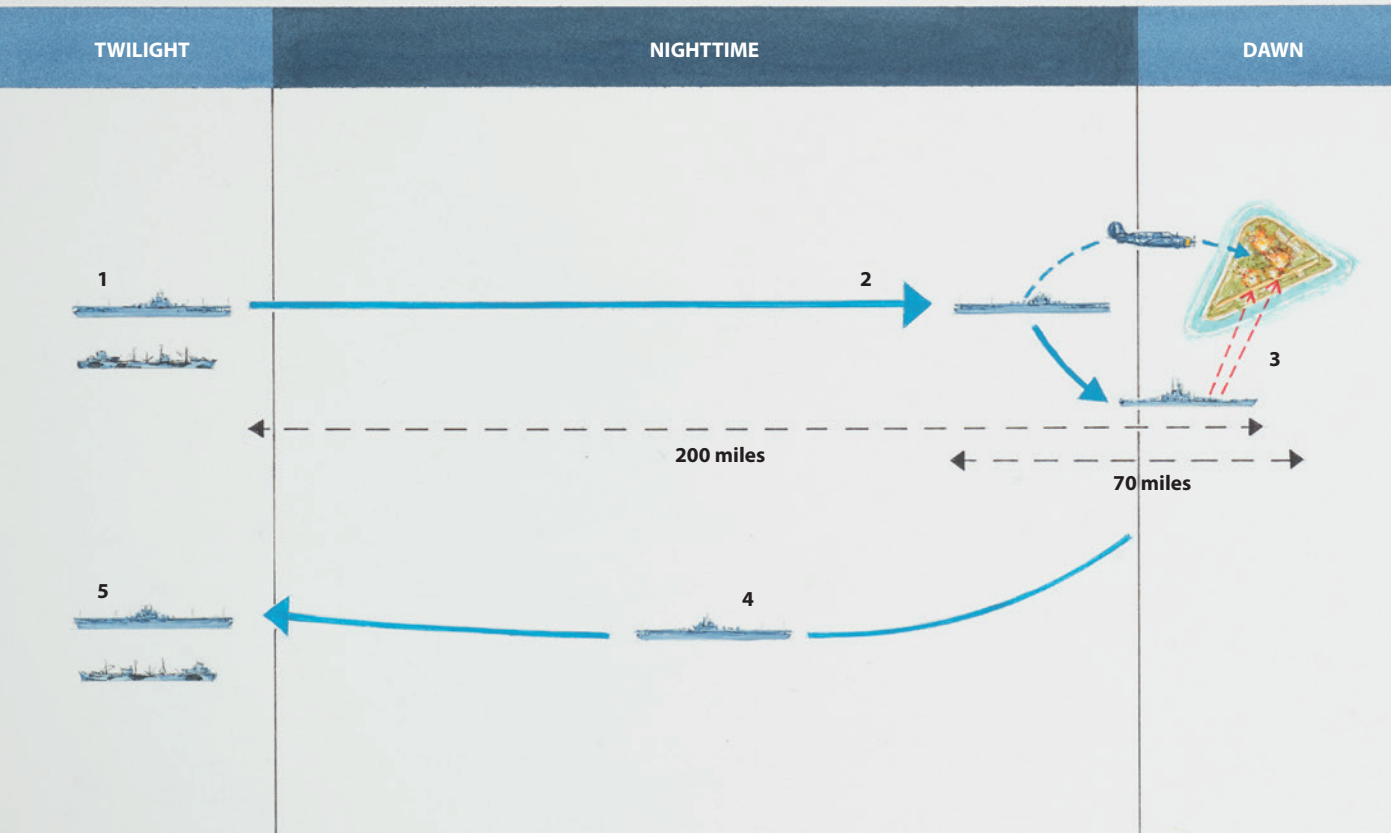
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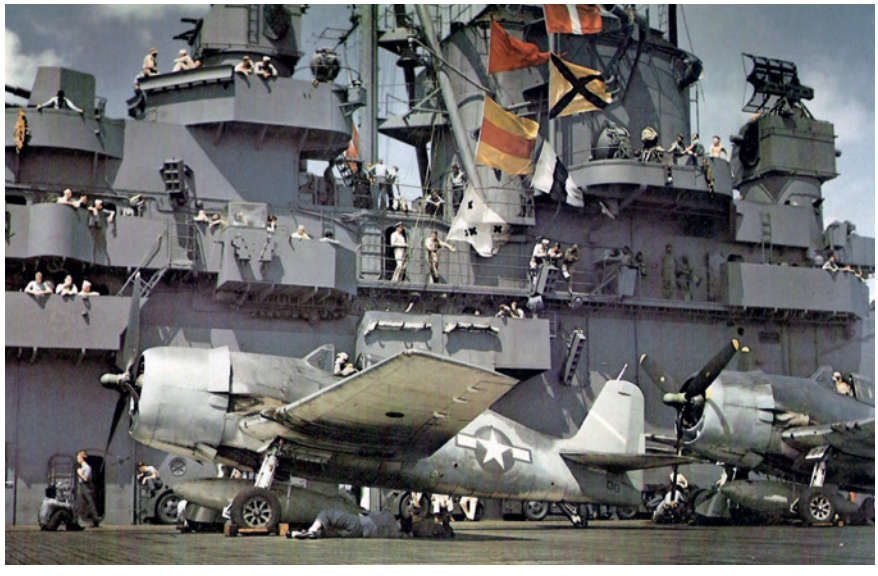


LtCdr Jimmy Flatley's F6F-3 Hellcat prepares to launch from USS *Yorktown* (CV-10), August 31, 1943. The Marcus Island strike initiated the new Fast Carrier Task Force's series of practice raids, which preceded November 's Operation "Galvanic." Flatley and his close friend LtCdr "Jimmy" Thach proved to be the wartime fast carriers' premier air tacticians, eventually becoming the air operations officers of respectively TF-58 and TF-38. This carrier's diagonal white tail identification stripe is visible here, but the photo bleaches out the shades of the February 1943–March 1944 tricolor camouflage scheme (Non-Specular Sea Blue uppers, Intermediate Blue sides, and white undersides) – see page 13. (Wikimedia)

In 1940, Rear Adm King's General Board report redefined the pre-task force US Fleet into the Battle Force (battleships, light cruisers, and destroyers), and the Scouting Force (cruisers and destroyers). The carriers were now administratively and tactically independent of the battleships, although still subordinate to the Fleet commander.

Wartime development, 1942–1943

The June 1942 Battle of Midway abruptly crowned the fast carrier as the USN's primary capital ship. The most significant lesson of the 1942 carrier battles was that existing US fighter-direction techniques were inadequate. Anti-aircraft firepower, however, continued increasing, through improved tactics, weapons, and technology. Additional guns per ship and additional screening ships accumulated alongside the fast carriers as they became available. Heavily-armed fast battleships were first used in a fast carrier's anti-aircraft screen in August 1942, with *North Carolina* proving "a distinct asset because of her demonstrated fire power against attacking aircraft and her inherent strength against possible surface contacts."

The primary wartime tactical controversy was whether carriers should operate together to coordinate air strikes and concentrate defensive firepower, or whether they should operate separately to avoid simultaneous discovery and destruction. The 1930s wargames erroneously convinced the USN that each carrier would destroy two enemy carriers per strike. Because a carrier discovered was seemingly a sunken carrier, carrier dispersal tentatively prevailed through 1942, although there were many dissenters. Enough new Essex- and Independence-class carriers had reached Hawaii by summer 1943 to allow experimentation. Combat analysis, advanced new radar and radio technology, refined fighter-direction techniques, heavier AA batteries, new 5-inch/38 proximity fuses, and efficiency-building trials off Oahu all converged

Ulithi, the world's fourth-largest lagoon, hosts Halsey's Third Fleet in this late 1944 photograph. With a depth of 80–100ft, Ulithi's anchorage could host 700 ships simultaneously. For an eight-month period between October 1944 and May 1945, this obscure atoll in the Caroline Islands was the greatest naval base in the world. (NARA via Mighty90)

towards multi-carrier Task Groups, allowing concentration of defensive power (AA fire and fighter patrols), while also facilitating coordinated, concentrated airstrikes.

On April 13, 1943, Adm Nimitz ordered a revamp of the existing *Standard Cruising Instructions for Carrier Task Forces*. The officers he assigned far exceeded their mandate, producing a completely standardized fleet-wide tactical manual incorporating wartime experience. The resulting *Pacific Fleet Tactical Orders and Doctrine* (*PAC-10*) was issued on June 10, 1943, and was revised the following year in *USF-10A: Current Tactical Orders and Doctrine, United States Fleet*. The new guidelines standardized tactics, yet also encouraged improvisation by allowing disparate combat units to be thrown together into coherent formations at short notice, allowing enormous flexibility in operations. *PAC-10* established "tactically concentrated" multi-carrier Task Groups, deferring offensive doctrine and tactical orders to Air Force, Pacific Fleet. On August 21, 1943 Air Force, Pacific Fleet released its new fast carrier doctrine, stating that carriers were the primary offensive power of the fleet and would attack the enemy on land and sea; would provide direct air support to amphibious invasions; and would provide air support to non-carrier task forces.

From practice to perfection, 1943–44

The new tactics and weapons were practiced in low-risk hit-and-run raids. The first was against Marcus Island on August 31, 1943 by Rear Adm "Baldy" Pownall's TF-15, comprising the carriers *Essex*, *Yorktown*, *Independence*, the battleship *Indiana*, two light cruisers and ten destroyers. This operation saw the first use of carrier-based F6F-3 Hellcats, "lifeguard" submarines, and the newly-resurrected concentric circular formation. The following day Rear Adm Arthur Radford's *Princeton* and *Belleau Wood* provided air cover for TF-11's occupation of Baker Island under Rear Adm Willis "Ching" Lee, successfully testing destroyer fighter-direction in the process. Weeks later, on September 18, 1943, Pownall's TF-15 of *Lexington*, *Princeton*, *Belleau Wood*, three light cruisers, and ten destroyers successfully struck Tarawa. Striking Wake Island on October 5–6, Rear Adm Alfred Montgomery's six carriers of TF-15 alternately experimented with one Task Group of six carriers, two Task Groups of three carriers each, and three Task Groups of two carriers each; all proved feasible. The new Hellcats dominated 30 defending Zeroes, a small Japanese retaliatory raid was easily repelled, and Montgomery's cruisers shelled the atoll. Wake was the last practice run; the planner of that strike, Capt Herbert Duckworth, claimed that "virtually all the techniques of ship handling for a multi-carrier force which were later used successfully had their origins in this operation."

The Fast Carrier Task Force's first major operation was "Galvanic," the November 1943 invasion of the Gilbert Islands. Such a huge and complex deep-sea amphibious operation had never been attempted before. Spruance assigned his 11 fast carriers to the invasion area in static defensive sectors, which grumbling carrier officers believed to be a gross tactical error. The aviators

The battleship USS *South Dakota* (BB-57) under repair in floating dry dock ABSD-6 at Guam, May 11, 1945. The immense task of sustaining a fully-functioning battle fleet right across the Central Pacific was achieved by introducing a system of mobile forward bases. Among their facilities, multiple dry docks large enough to service capital ships could perform routine maintenance and all but major repairs thousands of miles from home – a threat never anticipated by the planners of Japan's defensive strategy. (Navsource)

The oiler USS *Cahaba* (AO-82) simultaneously refuels USS *Shangri-La* (CV-38) and USS *Iowa* (BB-61), July 8, 1945. In the final months of the war a fast carrier could also take on 35–50 tons of ammunition an hour if the sea state was reasonable. This photo epitomizes the Fast Carrier Task Force: no other navy in the world matched the United States in the efficiency of its underway logistics, which was the key to the FCTF's relentless operational tempo. (Navsource)

believed that "success in the new war was based on the swift striking power of the fast carrier. Battleships could wait for the enemy fleet to sortie, but the carriers could not, for they were particularly vulnerable to air and submarine attack." For fast carriers, the best defense was maximum offense. After Operation "Galvanic," Spruance permanently assigned the fast battleships to the fast carriers. From then on, the FCTF would largely be unleashed for pre-emptive high-speed offensive attacks, led by an appropriately aggressive new commander, Marc Mitscher. Now called Task Force 58, by early 1944 this integrated combined-arms team of modern radar-equipped fast carriers, fast battleships, cruisers, destroyers, fighters, and bombers would mature into "the supreme instrument of command of the seas," becoming "unapproachable by surface ships, self-defending against aircraft, and able to strike at will for hundreds of miles in any direction beyond the circle of ocean it directly occupied."

A seaman manipulates cut-out model aircraft on the "ouija board" of USS *Randolph* (CV-15) to plan aircraft stowage, 1945. The near board represents the *Randolph*'s flight deck, and the far board the hangar deck. Careful organization allowed the USN to pack a larger air group aboard its carriers than any other navy. (Navsource)

Strategy and logistics

"Galvanic" was actually the first operation in the USN's long-studied War Plan Orange, which since as long ago as 1906 had hypothesized how to defeat Japan. After presumably losing the Western Pacific, a USN-led combined arms naval/amphibious force of warships, aircraft, and ground forces ("the Big Blue Fleet") would drive west through the Central Pacific from Hawaii, strangling Japanese commerce, retaking the Philippines, and finally forcing the IJN fleet to fight a decisive battle in Japanese waters, which the USN would win. Aircraft carriers had been a major element of War Plan Orange since the 1920s.

However, wargaming revealed that War Plan Orange always collapsed over the lack of established naval bases available to support the US fleet in the Western Pacific. The problem was solved in the 1930s by the conceptual breakthrough of modular "mobile bases" which

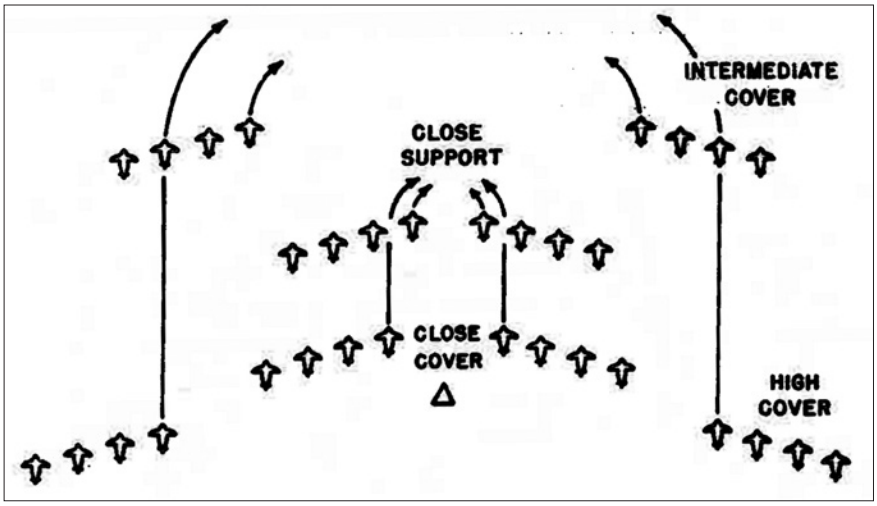
the US fleet would take with it. This revolution proved decisive in the 1943–45 Central Pacific campaign. By seizing the Japanese-occupied Marshall, Caroline, and Mariana island groups the USN judged it would obtain locations for "approximately 20 airfields, 15 seaplane bases, eight submarine bases, and ten fleet anchorages." Without the portable forward operating bases and highly developed supporting logistic system, the enormous strategic mobility, persistence, striking power, and operational tempo of the fast carriers would have been impossible.

The prewar Orange plans for the Central Pacific offensive were updated in December 1943 by Adm Nimitz's "Granite" plan. Under "Granite," Spruance's Fifth Fleet would maintain "unremitting pressure against Japan" and pursue the annihilation of "the Japanese Fleet at an early date." The independently-operating Fast Carrier Task Force would pre-emptively strike nearby Japanese island airbases to screen the slow, vulnerable amphibious force of transports, escort carriers, and old battleships from hostile air-sea counterattacks. Fast battleships were often detached from the FCTF to supplement the pre-landing bombardment, and the entire FCTF protected the landing forces against the hoped-for sortie by the IJN's Combined Fleet. *PAC-10* allowed the Fast Carrier Task Force's fast battleships and the Joint Expeditionary Force's slow battleships to assemble into a single battle line if threatened with a surface action. Provoking the IJN's Combined Fleet into the desired showdown was arguably the primary operational-level objective: "A major fleet action, although it may delay amphibious operations for a brief period, will greatly accelerate them thereafter." However, unresolved ambiguity over the FCTF's absolute priority during an amphibious invasion (aggressive pursuit/destruction of an approaching IJN fleet, or static defense of the invasion area?) would haunt both Spruance and Halsey in 1944.

In January 1944 the Fast Carrier Task Force sortied from Pearl Harbor for the last time, bound for Operation "Flintlock," the US invasion of the Marshall Islands. Although such landings were often costly to the landing forces, by 1944 Fifth Fleet's ability to bring overwhelming power to bear on isolated island outposts meant that actual operational defeat had become virtually impossible. After a successful US invasion, airstrips would be built or repaired ashore, and island garrisons and organic air units established. Operating aggressively out of the new forward bases, US naval and amphibious forces progressively conquered or leapfrogged Japan's Central Pacific island garrisons. Inevitably, US progress would leave the Fast Carrier Task Force's active anchorage far to the rear. A new forward anchorage would then be established, the rearwards base abandoned to caretaker status, and the sequence repeated.

A forward anchorage required a sufficiently large, deep lagoon or harbor to shelter the fleet, often at a nearly deserted coral atoll. Seabees built airstrips and recreation facilities ashore. Supplying the forward bases were dedicated service squadrons under Vice Adm William Calhoun's **Service Force Pacific Fleet**. Providing the main pool of logistics ships out of Pearl Harbor was **Service Squadron 8** (**ServRon-8**). Between March 1943 and March 1944 ServRon-8 increased in size from 44 to 430 service vessels, with 321 devoted to

A Fordson B-25 Moto-tug Tractor tows an F6F-3 Hellcat of VF-30 into position aboard the USS *Monterey* (CVL-26) in November 1943. With US carrier planes increasing in weight, in October 1943 each heavy carrier was issued four jeeps and seven Moto-Tugs, while each CVL received two jeeps and four tractors. They greatly assisted, but never replaced the deck crews' physical labor. (Getty Images)



Tactical diagram showing the prescribed strike escort method for 32 fighters. Eight are in close support near the bomber formation, with eight more in close cover behind and somewhat above, say at 15,000 feet. Further above the bombers (say 20,000ft), and in front on both flanks, another eight provide intermediate cover. Flying highest (say 25,000ft), and furthest astern and to the flanks, are the eight fighters in high cover. If high-cover fighters descended to fight, at least one division would remain at altitude in case additional enemy attackers appeared. (*USF-74B*)

Fifth Fleet. ServRon-8 encompassed fleet tankers, ammunition ships, stores ships, small cargo ships, hospital transports, oilers, small craft, water barges, garbage barges, and lighters, but was only commanded by a commodore. For November 1943's Operation "Galvanic," the fast carriers were supplied by **ServRon-4**, which was quickly supplanted by **ServRon-10**, aka the **Mobile Service Base,** established specifically to service the Fast Carrier Task Force. ServRon-10 drew from ServRon-8 at Pearl Harbor, and consisted of the entire cross-section of supply vessels available. As the "logistical counterpart for the airplane carrier," Nimitz called ServRon-10 his "open secret weapon."

Majuro atoll in the Gilberts was occupied on January 31, 1944, and four days later TF-58 anchored there for re-supply. ServRon-10's array of specialized vessels eventually included enormous floating drydocks that could lift a carrier or battleship; only ships requiring major repairs would be sent to Hawaii or the United States. In June 1944 ServRon-10 abandoned Majuro as the fast carriers' main anchorage for Eniwetok in the Marshalls. Next, Ulithi in the Carolines was occupied on September 24, 1944, and on October 1 Ulithi replaced Eniwetok as TF-58's main anchorage. By mid-October the Mobile Service Base (ServRon-10) of 40 vessels had transferred 1,400 miles west to Ulithi, including its 400,000-barrel capacity floating "tank farm" of 6–8 obsolete tankers. A fully-equipped airbase with a 3,500ft airstrip was constructed there, and a fleet recreation area capable of hosting 1,000 officers and 8,000 bluejackets a day was

D

COORDINATED DECK-LOAD STRIKE

These schematics represent a strike by 18 Helldivers (light blue) and 12 Avengers (dark blue) from a US carrier against a Japanese fleet carrier at a range of *c.* 200 nautical miles. For the sake of simplicity the escorting fighters are not represented here, but their dispositions are indicated in the diagram on this page. The **key numbers** refer to both the plan and elevation panels.

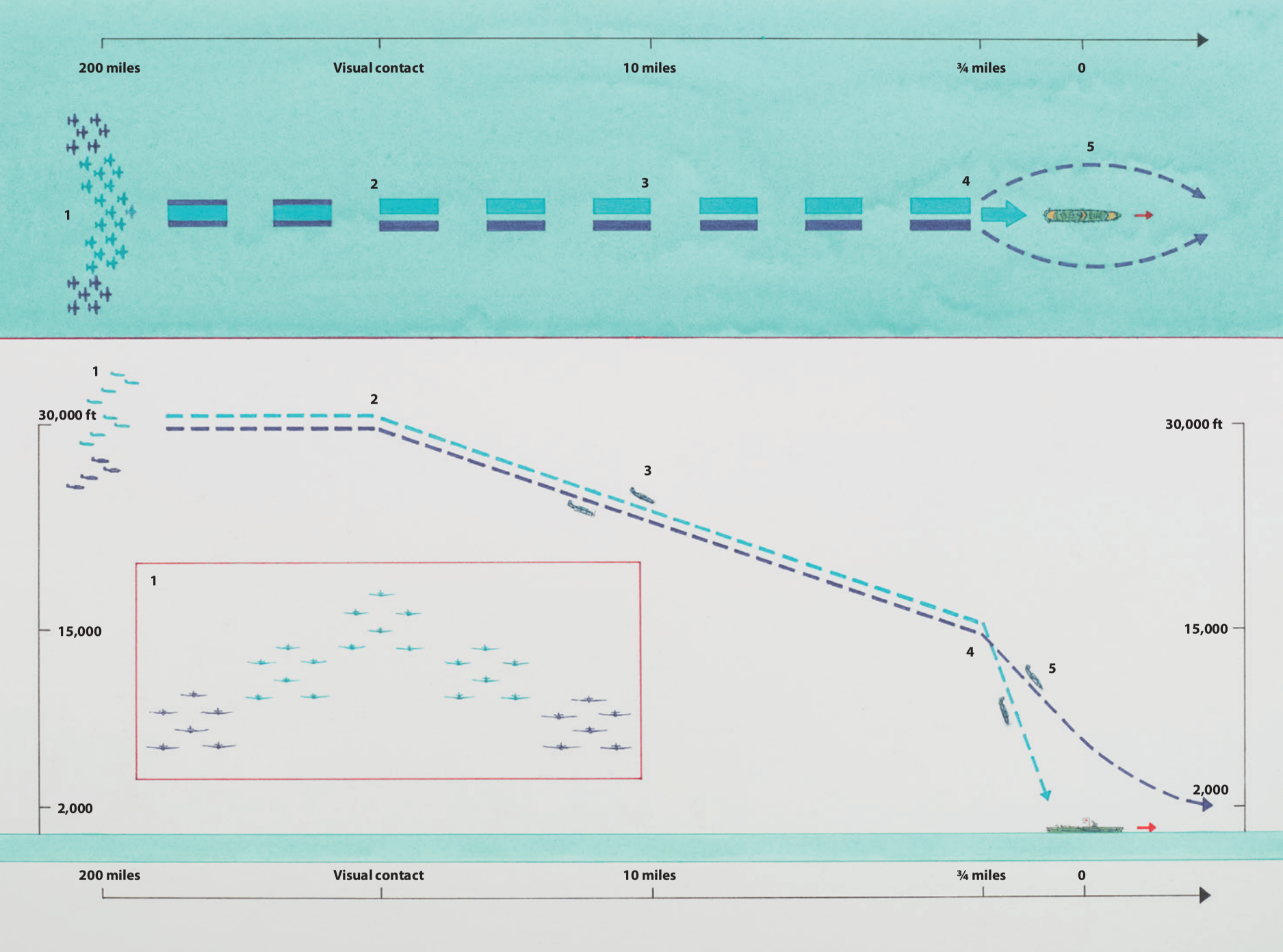
(1) Cruising altitude is 30,000ft, in the formation shown.

(2) Upon visual contact with the target, the Helldivers and Avengers and their assigned fighter escorts deploy into separate formations, but maintain common altitude, as the strike begins a shallow dive from 30,000ft to 15,000ft.

(3) When 10 miles from the target, the Helldivers deploy into individual six-plane divisions and begin a high-speed attack run, accompanied by their assigned fighters.

(4) At 15,000ft and a lateral range of ¾ to ½ a mile from the target, the Helldivers push over into 70-degree dives onto the Japanese carrier (also see Plate F).

(5) Once the Helldivers' bombs begin to strike, the Avengers begin their fast descent, aiming for a torpedo release point 5 miles ahead of the Japanese carrier's current position, which they should reach at 2,000ft altitude (also see Plate G). The Avengers' fighter escort stays with them throughout their torpedo attack runs.


200 miles
Visual contact
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1
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200 miles
Visual contact
10 miles
¾ miles
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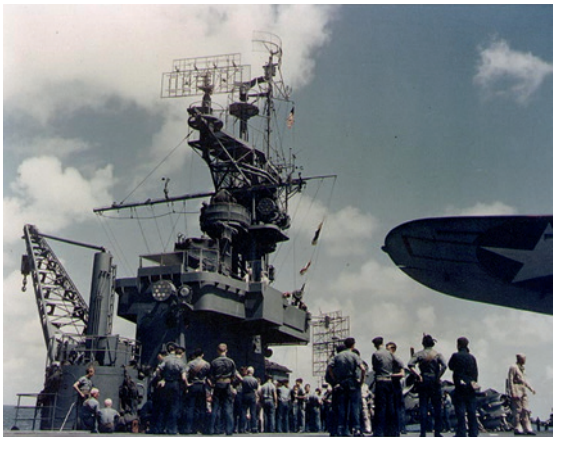
The *Yorktown*'s No. 3 elevator brings an F6F Hellcat up to the flight deck. Essex-class carrier flight decks and deck-edge elevators were made from 3in-thick planks of Douglas fir and Oregon pine; the former was preferred for its "give" and for its low inclination to splinter. Inboard elevators were made out of ¾-in Special Treatment Steel (STS) plating. Wood was preferred, because it was easier to repair at sea. (World War II Database)

A close-up of USS *Cowpens*' island, with a flight deck crane visible in the left foreground. In the event of a plane crash, air operations would be suspended and the carrier's mobile crane would clear the flight deck as fast as possible, often dumping the wrecked aircraft overboard. (Hyperwar)



completed by January 1945. Total Ulithi cargo handling averaged 32,000 tons per month. On June 1, 1945, Ulithi was replaced as the fast carriers' war anchorage by Leyte-Samar in the Philippines, and another base was established at Buckner Bay in Okinawa the following month. From Majuro to Buckner Bay, the distance of these bases from Pearl Harbor had progressed from 1,975 to 4,430 nautical miles.

The Fast Carrier Task Force's strategic mobility and high operational tempo were built on the USN's skill in and emphasis on at-sea replenishment. No other wartime navy so comfortably relied on at-sea refueling, giving the USN a significant operational advantage. After inventing the practice in 1917, the USN began consistently practicing "broadside" at-sea replenishment in 1939. Oilers originally approached the ships they were to refuel, but in November 1943 Capt Truman Hedding decided "We all know how to fly formation. Let's set the tanker up there, and let everybody come up and make an approach on the tanker and just run the fuel lines across." Carriers always approached an oiler's port side so that both ships were in full view from each other's bridge. An oiler could refuel a large ship and an escort simultaneously – up to 6,000 barrels per hour to a carrier or battleship, 4,000 barrels per hour per cruiser, or 2,000 barrels per hour per destroyer. Because destroyers typically needed refueling every third or fourth day, they were often refueled directly by carriers or battleships, especially in combat zones.

The **At Sea Logistics Service Group** (**TG-30.8**) was established in October 1944 specifically to re-supply TF-38 at sea. It comprised 34 oilers, 14 ammunition ships, 11 escort carriers, 19 destroyers, 26 destroyer-escorts, and 10 fleet tugs – all under the command of a captain. TG-30.8 was divided into 10–12 replenishment Task Units of three oilers each; four replenishment Task Units comprised a replenishment Task Group.

The 1944 Leyte invasion demonstrated that carriers attacking ground targets exhausted aviation ordnance after three to four days of intensive action. **Service Squadron 6** (**ServRon-6**) was accordingly established on December 5, 1944, to "furnish direct logistic support to the Fleet, in and near the Combat Zone, in order to maintain the mobility and striking power of the Fleet." ServRon-6 would supply fuel, food, ammunition, airplanes, clothing, general stores, pilots, and personnel. Because ServRon-6 would operate in the combat area, it would be capable of fleet speeds and be assigned escort carriers, destroyers, and destroyer-escorts.

ServRon-6 assembled at Eniwitok and Ulithi in February 1945, and was designated **Logistic Support Group Fifth Fleet** (**TG-50.8**). On March 13, 1945, Rear Adm Donald Beary's TG-50.8 sortied from Ulithi with the Omaha-class light cruiser USS *Detroit* (CL-8), 16 oilers, 4 ammunition ships, 4 fleet tugs, 2 airplane transports, 2 escort

carriers, 12 destroyers, and 7 destroyer-escorts. Between March 27 and May 17, 1945, TG-50.8 dispensed or consumed 8.7 million barrels of fuel (90 tankers' worth), 259,000 barrels of diesel oil, and 21.5 million gallons of avgas – more petroleum than Japan had produced or imported in 1944. During a three-week period in April 1945, TF-58 consumed, *per day,* 167,000 barrels of fuel oil and 385,000 gallons of gasoline, requiring 30 oilers. (The avgas capacity of Essex- and Independence-class carriers was 242,000 and 122,000 gallons respectively.)

Carrier strikes against the Home Islands began in February 1945. After striking Japan for one or two days, TF-38 would retire overnight to rendezvous with the replenishment group at dawn. Three to four oilers, followed by three to four ammunition and provision ships, would line up at 10kts, spaced 1,500–2,000 yards apart, and TF-38 would then approach to be replenished. Over 100 warships would line up over 40nm, making successive runs on oilers, ammunition ships, and stores ships. Two days of strikes required two overnights and one day to replenish before strikes resumed, compared to 10–12 days lost if the FCTF had returned to the nearest base. Unengaged oilers would consolidate fuel, emptying others to return to Ulithi or Leyte, where commercial tankers from California awaited them. This system of floating logistic support largely freed USN task forces from the limitations of fixed shore facilities.

FLIGHT OPERATIONS

Personnel and procedures

A captain commanded each carrier, and its various departments (navigation, air, gunnery, construction, engineering, supply, and medicine) reported directly to his second-in-command, the executive officer (XO.) Air operations were conducted by the air department, commanded by the air officer**.** The captain, executive officer, navigator, and air officer were all aviators. Under the air officer were the ACI (Air Combat Intelligence) officer, ordnance officer, flight deck officer, hangar deck officer, landing signals officer, engineering officer, catapult officer, arresting gear officer, gasoline officer, photographic officer, and the embarked CAG itself, including the CAG commander, who assisted the air officer in the planning and conduct of operations. By late 1944 an Essex-class carrier embarked 958 aviation-related personnel (44 officers, 914 enlisted) in addition to the CAG itself.

When conducting flight operations, carriers turned at high speed into the prevailing wind; steaming at, for example, 20 knots into a 10-knot headwind generated 30 knots free airspeed for an airplane on deck, greatly shortening take-off runs. The same applied to landing. When a single carrier was launching or recovering patrols, it would maneuver into the wind independently of the Task Group. When the entire Task Group was conducting air operations, such as launching strikes, the entire Task Group would steam into the wind. Before flight operations began, the "plane guard" destroyer

Landing Signals Officer Lt (JG) Walter F. Wujcik wields highly visible paddles with cerise streamers to bring a plane aboard the light carrier *Belleau Wood*, 1945. Wujcik's reflective suit will allow him to be seen better at night, when he will be lit up by a UV spotlight. The LSO's station was on the port stern, facing backwards, so a special windscreen protected him against the 30-plus knot headwind at his back. (Navsource)

F4U-2 Corsair night fighters of VFN-101 prepare to launch from the USS *Intrepid* (CV-11) during the early 1944 Marshall Islands campaign. Folding the wings on deck often caused wing-mounted radars to malfunction from moisture accumulation – a six-hour rainstorm once caused all 20 of a CVG(N)'s exposed aircraft radars to fail. (Wikimedia)

(designated by daily rotation) would take station 1,000 yards astern of its assigned carrier to rescue survivors from launch or landing crashes.

US carriers were built with light, easily-repaired wooden flight decks, allowing larger CAGs but also permitting larger, faster elevators between single-story hangars to hasten launch cycles. To further maximize CAG size, the USN developed the deck park. Hangars were intended for extra storage space and for aircraft repairs. The deck park demanded that all aircraft "spotted" on deck be launched in rapid sequence, thus reducing the amount of fuel burned by aircraft circling while the strike formed up.

The flight deck was divided into control sections. "Fly One" was the forward launching and catapult area, under the control of the flight deck officer and catapult officer. Amidships was "Fly Two," controlled by the taxi signal officer. The landing area aft was "Fly Three" under the landing signals officer (LSO) and the arrestor gear officer. Nicknamed "airdales," carrier flight deck and hangar crew were organized by job and wore color-coded uniforms. Brown Shirts were plane captains, described as "like a squire to a knight." Aircraft elevators, catapult equipment, and arresting gear were manned by Green Shirts (hydraulics). Plane pushers were Blue Shirts, acting under Yellow Shirt plane directors, usually petty officers – the flight deck's "traffic cops." Various avgas outlets were located around the flight deck; next to the island were bomb elevators and a torpedo elevator, all these being manned by Red Shirts.

Readying a strike for launch took 30–60 minutes. Enterprise- and Essex-class carriers had open hangars, meaning aircraft could be warmed up below (this took 15–20 minutes). Elevators brought the aircraft on deck two planes at a time. Enterprise- and Essex-class elevators had a 45–second cycle (13 seconds up, 12 seconds down, plus 10 seconds each to move planes either on or off). Aircraft were manhandled into position by Blue Shirt plane-pushers.

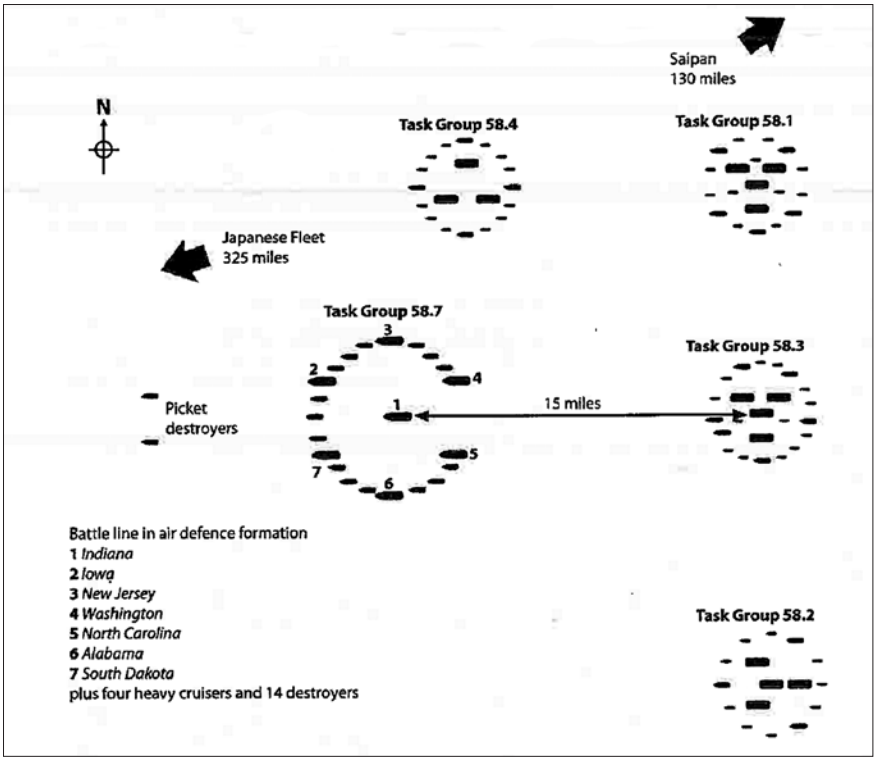
Prewar doctrine had spotted 1941's entire 73-plane CAG on deck, as far aft as possible for maximum takeoff roll. Lightweight fighters required the shortest takeoff and were arranged and launched first, followed by heavier dive-bombers, and finally the heaviest torpedo-bombers. All were to be launched in one continuous operation, ideally within 20 minutes – a "full deck-load strike." By 1942 aircraft were heavier and required longer takeoff rolls, so the entire CAG could no longer be spotted on deck. Mitscher's May 1944 special Task Force instructions, *FasCar TFI-1*, emphasized the "coordination of the many attacking groups in order to obtain a maximum

delivery of strikes … in an orderly and continuous flow. This can best be accomplished by roughly dividing the air groups in half and launching 'deck loads' at a time, each 'deck load' a complete striking group." This method was termed the "two-strike cycle" (see Plate C).

The finite airborne endurance of aircraft made launch-and-recovery cycles complex juggling acts, and organization, speed, and efficiency were critical to safely operating large CAGs. By 1943 carriers increased their strike size by spotting aircraft with wings still folded, only unfolding them moments before launch. Because aircraft took only half the length of an Essex-class flight deck to launch or land, one elevator could bring aircraft up to the flight deck before launch, or strike aircraft below during landing. Theoretically carriers could launch and recover aircraft simultaneously, but this was rare in practice.

Although US fast carriers were equipped with one to three hydraulic catapults, the deck-roll method was preferred because it was much faster for launching large strikes; it took about 10 seconds to launch a plane by deck-roll, compared to 30 seconds by catapult. However, increasing aircraft weights meant that by 1945 fast carriers launched 40 percent of their sorties via catapult. Launching aircraft on the downward pitch of the flight deck was obviously to be avoided, so an excessively pitching carrier slowed launch rates.

A US fast carrier could move 60 miles by the time its strike returned. The carrier's expected location was planned ahead of time and called "Point Option," and its coordinates and other information were posted in squadron ready rooms and on the carrier island. Assisting the returning flyers was the YE-ZB system: even when under radio silence the carrier would transmit its YE homing beacon, in the form of a different two-letter Morse code



An overhead diagram of the full Fast Carrier Task Force (TF-58) at the battle of the Philippine Sea, June 19, 1944; it is divided into five Task Groups. Hoping for a decisive surface action, Adm Spruance insured that his fast battleships would be extracted from the carrier Task Groups well before the chaos of battle; the resulting battleship Task Group 58.7 is in the van of the Task Force, 15 miles west of carrier Task Group 58.3. Admiral Mitscher's air staff pleaded for an aggressive overnight dash by the entire Fast Carrier Task Force, assuring the fast battleships of a night-time clash with the IJN fleet, but the conservative battleship-trained admirals Lee and Spruance considered the scheme too risky. (Courtesy Battleship NORTH CAROLINA)

View of an unmanned Independence-class Combat Information Center, July 1944. Various CIC elements visible include e.g. a Talk Between Ships (TBS) VHF radio speaker, a status board, a gyro repeater, the vertical plotting board, two plotting tables, and a remote Plan Position Indicator (PPI). Already crowded during an action, the CIC's drama (and air-conditioning) frequently attracted unnecessary visitors: it was to deter these, as well as to improve survivability, that carrier CICs were installed below the hangar deck. (US Navy)

for each 30-degree navigational "pie-slice" of the compass, such as AA, ZZ, and so on. The 12 sector codes were relayed to pilots before takeoff, and changed daily for security. Maximum range was 275nm; distance to the carrier could be determined by the altitude at which the beacon could be detected by the plane's ZB receiver – about 80nm at 8,000ft, and subtracting 10nm for every 1,000ft loss of altitude.

Upon reaching the carrier, returning squadrons entered an offset holding pattern (typically left-handed, which is why US carrier islands are to starboard). Upon successive commands from the carrier, one squadron at a time then descended into a 1,000–500ft altitude oval pattern over the carrier, and separated into divisions. From here, one division at a time would descend into a 300–100ft altitude pattern, before separating into individual planes 20 seconds apart. Deck personnel visually confirmed that arrestor hooks were extended. Landing gear was lowered on the final downwind leg, with the final approach a descending, left-handed half-circle turn from port astern onto the deck. Once 200 yards astern, 60–40ft above the flight deck, and 10–15mph above stalling speed, the pilot was in the "groove" and began taking directions from the landing signals officer. The brightly-clad LSO, himself a qualified pilot, used standardized body language and hand paddles to direct the incoming pilot while landing. Only two orders were mandatory – the "wave off" aborted the landing and returned the plane to the pattern, while the engine "cut" signaled a sharp throttle-down that dropped the plane onto the deck in a successful landing.

Night operations

By 1943 the IJNAF began increasingly resorting to night torpedo-bombing attacks, which existing CAGs were unable to defend against. By January 1944 the fast carriers had developed a minimum night fighter capability. Each heavy carrier CAG developed two "Bat" night combat teams, each composed of one Avenger and two Hellcats. Fighter directors and radars would help maintain visual contact to avoid friendly fire. *Enterprise* and *Intrepid* were additionally augmented with night-trained four-fighter Corsair divisions, while *Bunker Hill* and *Yorktown* received four-plane divisions of night-trained Hellcats.

By December 1944 the F6F-5N Hellcat had replaced the F4U Corsair as the standard night fighter. F6F-5Ns were equipped with radio altimeters and the APS-6 airborne radar, which could detect a carrier from 22nm. Installing a second ARC-1 radio per Hellcat facilitated the two-way positive radio control necessary for night flying. TBM Avengers deployed the ASD-1 airborne radar, which could detect a carrier from 40nm away. The Avenger's unnecessary defensive armament and ventral armor were removed, improving range and bomb load, but requiring 14 pounds of lead be installed in the extreme tail to restore proper trim.

The unforgiving nature of night flying over the ocean demanded superb maintenance of engines and radios to ensure peak operating efficiency for night missions. The LSO used special 36-inch illuminated wands and a VHF set to communicate with pilots, and a stern-facing ultraviolet floodlight illuminated the LSO's glowing night-suit. Carriers used standard night lighting, except that flush deck lighting was replaced by "Victory Lights," which were vertical white-painted 6 x 21-inch rubber studs illuminated from beneath by a small deck-mounted light. Victory Lights proved superior in outlining the deck and providing depth-perception to pilots; an *Enterprise* report noted that after their introduction "not a single plane has gone over the side."

In fact, the biggest single issue with night flying was ensuring that crew got sufficient sleep; during daytime the Task Force would be conducting operations, if not actually fending off attacks. Additional officers and trained specialists were often required for a "night carrier." Typically, just one LSO could be expected to be night-qualified at the beginning of a tour; he would train additional LSOs for night-time operations, which might take two months.

An enlisted man updates data at a Combat Information Center's vertical plotting board, 1944–45. On the other side are additional sailors, who have mastered the necessary CIC art of writing backwards. The vertical plotting board was constructed from a sheet of transparent Plexiglas; when edge-lit, it caused grease-pencil writing to glow. The USN's fighter direction technology and practices were copied in 1941 from the RAF's example observed during the Battle of Britain, but a prototype British-style vertical plotting board was only adopted after the RN carrier HMS *Victorious* was repaired at a US yard in 1943. (US Navy)

The battle of the Philippine Sea further revealed the fast carriers' night-fighting deficiencies. After June 1944, all aviators were required to qualify for night landings. By July 1944 Adm King had approved a night carrier group of *Enterprise* and the light carriers *Independence* and *Bataan,* and several night detachments were cobbled together at Pearl Harbor to form the first night air group. CVLG(N)-41, with 19 F6F-5N Hellcats and 8 TBM-1D Avengers, sortied aboard *Independence* on August 17, 1944. Night Carrier Division 7 was activated on December 19, 1944 under Rear Adm Matt Gardner. Weeks later *Bataan* was removed from night specialization, leaving *Enterprise*, *Independence*, and six destroyers operating independently as TG-38.5 at night, then cruising under the cover of TG-38.2 by day.

Light carriers proved too small for night operations. In February 1945 *Saratoga* replaced *Independence* on night duty, and TG-38.2 became TG-58.2. On February 21, *Saratoga* was detached and *Enterprise* became solely responsible for night-time CAPs over Iwo Jima. Beginning on February 23, *Enterprise* operated her aircraft for 198 out of 200 hours, including 174 hours straight, before being detached that April. In July and August, *Bon Homme Richard*'s CVG(N)-91 would conduct twilight/night sweeps and CAPs, notably defending the fast battleships during their bombardments of mainland Japan. Nevertheless, Adm Mitscher in particular disdained fast carrier night operations, which remained controversial and inconclusive through August 1945.

TASK FORCE TACTICS

Formations & communications

A vital 1941 innovation was Talk Between Ships (TBS), a short-range 50-watt VHF voice radio transceiver transmitting between 60–80 MHz, which was developed by RCA and the Naval Research Laboratory. TBS's short

range (line-of-sight or about 10nm) allowed ship-to-ship communication in "clear" (unencrypted) without fear of enemy interception. The standard 12nm interval between Task Groups exploited the line-of-sight range of visual signaling and TBS, allowing mutual defense and communication. Independent "linking" destroyers could deploy between Task Groups to facilitate relayed communications.

A carrier Task Group's standard speed was 15 knots, with flank speed 25 knots. Carriers always deployed in the center of a Task Group, with battleships and cruisers surrounding them in the innermost ring to provide the heaviest AA protection. Destroyers comprised the outermost ring, or deployed adjacent to the carriers if insufficient heavy ships were available. Night-time picket destroyers deployed 12nm from the Task Group's center, and excess destroyers slotted between the carriers or deployed as additional pickets. Standard cruising disposition was the circular, 12,000-yard (5.9nm) wide formation 5-R, while the primary anti-air defense (battle) formation was disposition 5-V (see Plate A), which provided for a denser AA curtain by contracting the Task Group into a 6,000-yard (3nm) circle.

All maneuvers in 5-V were communicated as "emergency" turns, broadcast over TBS by the flagship as: "*This is [Task Group … commander]. All ships emergency turn to course …*" All ships turned instantaneously on this command, the Task Group turning as one. When enemy aircraft committed to torpedo runs, the Task Group emergency-turned to put the torpedo planes abeam, allowing maximum anti-aircraft fire from the destroyers. If the enemy penetrated the destroyer screen, another emergency turn maneuvered the carriers' sterns to the enemy, presenting the smallest target, and forcing the torpedo-bombers to chase the carriers and endure a longer attack run through battleship, cruiser, and carrier AA fire.

As carriers were added to or detached from the Fast Carrier Task Force, individual Task Groups were formed or dissolved as necessary. Admiral Mitscher preferred four carriers per Task Group, believing any

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FIGHTER TACTICS

(Top) The "Thach Weave"

The basic air-to-air defensive tactic was the Thach Weave, devised by LtCdr John S. "Jimmy" Thach of VF-3. It is shown here executed in its simplest form by a section leader (light blue) and his wingman (dark blue). Leader and wingman normally maintained a tactical distance between them equal to their turning radius.

(1) When an enemy fighter got onto a US fighter's tail, both leader and wingman turned towards each other.

(2) This exposed the enemy to head-on fire if he followed, or a deflection shot if he disengaged.

(3) Leader and wingman then resumed their tactical distance. Despite its simplicity, both American and Japanese pilots agreed that the "Weave" proved extraordinarily effective.

(Inset) F6F-3 Hellcat fighter of VF-16, embarked on USS *Lexington* (CV-16), 1944.

(Bottom) Strafing attacks

A well-executed strafing attack, with no two planes following exactly the same approach path, reliably frustrated the anti-aircraft gunners on enemy ships. Aggressive fighter strafing runs against an enemy ship were intended to suppress AA fire immediately preceding the Helldivers' and Avengers' attacks (see Plate D). This schematic represents a strafing attack on a Japanese Yamato-class battleship. This fighter division expects possible enemy fighter opposition.

(1) The attacking fighter division approaches the target in sections line abreast, at 8,000–6,000ft altitude.

(2) Lateral separation is increased when the leader signals by rocking his wings.

(3) Converging on the enemy ship with their section leaders, the wingmen swing out at the beginning of the final approach; separation was required to avoid the leader's showers of empty shell cases. Once in position the leading section begins its final dive at 45-60 degrees, immediately followed by the second section from the other direction. The fighters open steady, well-aimed fire at 4,000ft altitude, and continue until pull-out; long and intense strafing runs required short bursts to avoid gun damage.

(4) The sections pull out of their dive at about 1,000ft altitude, though targets liable to explode required a pull-out at 2,000ft.

(5) The leading section pulls out slightly high to clear the area for the following section, then turns towards the second section's pull-out to maintain tactical concentration.

3
3
2
2
1
1

5
4
4
3
2
1
Following section
3
2
1
Leading section

A quad 40mm Bofors crew practice target shooting aboard USS *Hornet* (CV-12) on February 13, 1945. The Bofors was loaded with four-round, 20lb clips (held here by the second loaders, left) into a two-clip hopper feed, allowing near-continuous fire – note the ejected shell cases covering the floor of the gun tub. Minimum crew for a quad 40mm was 11: gun captain, pointer, trainer, and four second loaders passing ammo clips from the ready rack to the four first loaders, who each loaded their own gun. The Swedish-designed Bofors led all USN AA guns with 33 percent of total wartime claims. An official historian argued that it "contributed as much as any other weapon to saving the warship from the oblivion which was so freely predicted for it by air power experts during the early part of the war." (Wikimedia)

less made uneconomical use of screening vessels, while any more overcrowded air operations. When conducting strikes, the FCTF typically deployed its Task Groups in column, which aided air operations.

Radar

Radar's revolutionary impact on US carrier operations is impossible to overstate. Before radar, it was largely accepted that defending a carrier from enemy air attack was nearly impossible – there was simply no time to intercept the incoming raid after it was discovered. However, by detecting air attacks far beyond visual range, radar allowed the defense time to allocate finite resources to meet the incoming threat. Skilled use of radar intercepts enabled US carriers to become first defensible, and in time virtually invulnerable to conventional air attack. Radar also eliminated the prewar fear of carriers blundering into a surprise surface encounter.

Radar was first installed aboard a US carrier in July 1940. By 1943 the Essex class mounted two SG surface-search radars, and two air-search radars – the long-range SK and the back-up SC-2. The primary SK air-search radar could detect incoming planes to 80nm, allowing about a 16-minute warning (although outstanding conditions allowed a large raid on June 19, 1944 to be verified by two battleships' SK sets from 141nm.) The first height-finding radar, the SM, was installed in March 1943; the tight-beamed SM had to be "coached" onto target by an air-search radar before locking on. A smaller version of the SM, the SP, would be installed aboard carriers, battleships, and cruisers. Because radars had blind spots, especially below, and could still fail or be jammed, visual detection remained critical, especially against low-flying attackers.

Fighter direction tactics

The USN adopted the RAF's fighter direction tactics, technologies, and organization observed during the 1940 Battle of Britain. The RAF's centralized fighter control center was first copied and installed in the carrier USS *Hornet* (CV-8) in July 1941. All relevant sensor and navigation data aboard (including visual information from lookouts) were collated into this single physical location, called Radar Plot. Here a highly-trained Fighter Direction Officer (FDO) could receive and evaluate information, plot the developing air situation, identify and designate incoming raids by vector and Roman numeral, and dispatch friendly fighters to intercept. Centralized communications linked Radar Plot to all radar and fire controls, look-outs, ship control, and fighter controls. By November 1942 the continuously-evolving Radar Plot was renamed the Combat Information Center (CIC), and one was ordered retrofitted aboard every ship no matter how small. Essex-class CICs were outfitted with one large vertical plotting

board (summary board), two smaller plotting tables devoted to specific interceptions, large status boards, and repeater displays of radar data.

The OTC (officer in tactical command) commanded the Task Force or Task Group, but delegated much air-control authority to the fighter directors in CIC. The CIC was almost always manned by young reservists (both officers and enlisted) who were at ease with new technologies and methods, rather than Annapolis graduates or career bluejackets. By 1944–45, fighter direction officers were always young (early/mid-20s), college-educated, quick-thinking, resilient under stress, and graduates of a grueling training program boasting a brutal student attrition rate. During a 1945 kamikaze attack, the entire Fast Carrier Task Force was essentially entrusted to the tactical skill of a single 24-year old lieutenant wielding a radio microphone. Excellent FDOs exhibiting "brilliant fighter direction and concise instructions" were highly sought-after. The overall Task Force fighter director typically delegated individual Task Group fighter direction to their respective Task Group FDOs, although he might order unengaged Task Group CAPs to assist other Task Groups that were under attack. Fighter direction was typically performed from carriers, but could be delegated to any ship in the Task Force.

FDOs communicated via the short-range, 100–155MHz four-channel VHF (Very High Frequency) radio, developed and installed aboard US fast carriers by summer 1943. Its high frequency prevented it from being intercepted and its four channels allowed four separate conversations. Typically, the fighter director was assigned a channel to control fighters, Air Plot a channel to communicate with strikes, and a third channel communicated between Task Group/Force CICs on separate ships.

In late 1943, improved Identification Friend or Foe (IFF) equipment, of the Allied-standardized single-band Mark III system, was installed in all US ships and aircraft. Appropriately equipped Allied radars transmitted an electronically coded "interrogation" to unidentified aircraft in what the USN called the "A" band. Allied planes' IFF transponders (which needed to be switched on) automatically transmitted the appropriate response, greatly decreasing friendly fire incidents. The Mark III also transmitted in a fighters-only "G" band, identifying friendly fighters available for organizing a radar-directed interception.

Early radar scope displays had required considerable skill and training to interpret. The Plan Position Indicator (PPI) scope, introduced in 1942, finally displayed radar contacts in the intuitive and now-familiar circular chart-style format, with a sweeping ray emanating from the center representing the rotating radar beam. Radars and the PPI were augmented by the Dead Reckoning Tracer (DRT), a mechanical navigation computer connected to the ship's gyros, which allowed continuous position tracking through real-time dead reckoning. When used together, the SG surface search radar, PPI radar scopes, DRTs, and TBS communications revolutionized at-sea navigation and enabled effective multicarrier Task Groups by allowing accurate, high-speed station-keeping in all weather conditions.

TASK GROUP DEFENSE

The fast carriers' best defense was simply to avoid discovery, by a black-out of long-range radio communication. Visual camouflage was intended either to conceal individual ships from aerial or submarine detection, or to confuse submarines' ranging by "dazzle" schemes.

A line of picket destroyers called a Surface Scouting Line often deployed 30–40nm ahead of the Task Groups as a reconnaissance-in-force against enemy submarines and light surface forces. The February 1945 Tokyo raids saw 14 destroyers deployed in a 60nm-wide picket line ahead of the Task Groups. Beginning in November 1943, specially assigned destroyers deployed for radar picket duty 50–60nm ahead of the Task Groups to extend forward radar coverage.

When not engaged in high-intensity combat, a single Task Group was often designated as the day's duty group, and flew anti-submarine patrols (ASPs), fighter patrols, and reconnaissance for the entire Task Force. Submarine periscopes could be spotted visually or on radar, allowing submarines to be attacked with depth bombs, torpedoes, or strafing. The CAGs and the destroyer screens provided the Fast Carrier Task Force's entire ASW capability. When transiting straits, the Task Groups fell into column and strengthened their ASPs aloft.

Aerial defense

A Task Group's primary anti-air defense was its Combat Air Patrol (CAP), assembled from four-plane fighter divisions. During good weather each Task Group maintained a Day Combat Air Patrol (DCAP) of at least eight fighters; during poor weather the CAP was maintained on deck ready to launch within ten minutes. CAP orbits were circular, oval, or figure-eight; the latter, perpendicular to the expected enemy threat, was preferred because it minimized the amount of time a pilot spent with his back to the enemy. The three basic CAP stations were:

Intercept station – above the carriers at 20,000ft, orbiting a 10nm-wide circle
Patrol station – above the carriers at 10–12,000ft, orbiting a 10nm-wide circle
Anti-torpedo station – outside AA range, in the direction of expected attack at 6,000–8,000ft, orbiting a 5nm-wide circle.

In 1943, CAPs were directed to orbit on the incoming strike's flight path between the carrier and the threat. By 1944, CAPs were to maximize their advantage by orbiting above and to the flanks of the expected inbound strike, but this required high tracking skill by the fighter controllers. The further out the raid was intercepted the better, but CAPs vectored too far out might miss the strike altogether, dooming the CAP to an unsuccessful tail chase. Ideally, defending fighters would be numerically equivalent or superior to the incoming attack.

When conducting strikes, each Task Group wielded a CAP of 60-plus fighters: 24 "airborne and stacked at various altitudes," eight more aloft on LOCAP (Low CAP) duty, 12 ready on deck to launch (Condition 10), and 16 more on 10-minute standby (Condition 11). For each four-fighter division assigned an interception, eight more fighters were launched. A CAP mission lasted 3–4 hours. Any particularly desperate scenario inspired a *"Hey, Rube!"* over the VHF, which recalled every airborne fighter, CAP or not, back to defend the carriers at all costs.

Anti-aircraft guns

The Task Group's second line of defense was anti-aircraft fire, which pursuing CAPs flew into at their own peril (unlike the Royal Navy, the USN did not cease fire for friendlies). By 1943 a highly effective three-tiered system of radar-directed AA batteries had emerged, which would be mounted aboard all US warships from destroyers up through 1945.

A Nakajima B6N "Jill" torpedo plane braves intense flak from the carrier USS *Yorktown* (CV-10) off Truk, April 29, 1944. On average it took thousands of rounds fired to knock down a single Japanese plane. US AA crews were trained to miss ahead rather than behind, so as to provide the psychologically intimidating effect of flying through visible flak. Causing the enemy pilot to miss the carrier was more important than shooting down the plane itself. Unsurprisingly, a major issue during low-level air attacks was friendly-fire casualties from rounds accidentally fired into nearby ships. (Getty Images 90958709)

The long-range weapon was the 5-inch/38 Dual-Purpose gun, controlled by the Mark 37 director (equipped with the FD Mark 4 or Mark 12 fire control radar). The 5-inch/38 had a 37,000ft ceiling and theoretical range of 18,200 yards (9nm), with a nominal rate of fire of 15–20rpm. Most rounds were manually fuzed to detonate at the enemy's judged altitude. Developed in secret at Johns Hopkins University, the revolutionary VT (Variable Time) or proximity fuze was introduced in 1943. A tiny radio transmitter-receiver in the VT fuze nose bounced radio waves off the target and measured the return time. When the VT shell was within lethal range (70ft), it automatically detonated. VT fuzes proved four times as effective as the earlier Mark 18 time fuze.

Medium-range defense was provided by the water-cooled, power-driven 40mm Bofors. The Swedish-designed Bofors was deployed in twin and quadruple mounts, controlled by the Mark 51 director, and equipped with tracers. Effective range was 2,000 yards, and nominal rate of fire 160rpm.

The Swiss-designed, air-cooled 20mm Oerlikon provided short-range defense, some being equipped with the Mark 14 gyro gunsight. The 20mm had an effective range of 1,000 yards, and was deployed in single and twin mounts. By late 1944 the kamikaze threat had rendered the Oerlikon obsolete – the 20mm simply lacked the knock-down power to stop a diving airplane.

When expecting air attack, the Task Group would be maneuvered to keep as many AA batteries unmasked as possible, but individual maneuvering was limited to bringing more weapons to bear or when under direct attack; ships were to maintain tight formation to keep fire concentrated. Standard doctrine was to open 5-inch/38 fire at 12,000 yards, using a high percentage of VT fuzes. The screen concentrated AA fire on torpedo-bombers, masthead-height bombers, and kamikazes, while the carriers fired on dive-bombers. When under night-time attack the escorts opened fire, but the carriers remained dark to avoid revealing their position, only firing automatic weapons at low-flying aircraft. The final defensive measure was evasive maneuvering.

The Cleveland-class light cruiser USS *Birmingham* (CL-62) plays fire hoses onto the burning light carrier USS *Princeton* (CVL-23) on October 24, 1944. Coming alongside burning carriers was inherently dangerous, since a fleet carrier's magazines might hold up to 2,000 bombs, 50 torpedoes, and 4,000-plus rockets. Sometime after this photo was taken *Princeton*'s torpedo magazine exploded catastrophically, killing 239 of the *Birmingham*'s crew and wounding another 408. The *Birmingham* survived, but Adm Mitscher ordered *Princeton* scuttled. (Getty Images 50691143)

Tactics against *kamikazes*, 1944–1945

Japan's introduction of suicide-attack *kamikaze* tactics from October 25, 1944 was a direct acknowledgment of the growing invulnerability of USN forces to conventional aerial attacks, and the increasingly remote chances of Japanese pilots surviving them. Kamikazes were intended to overwhelm CIC fighter directors by saturating USN defenses with too many threats approaching from too many different directions and altitudes to be countered. Kamikazes could nevertheless expect to suffer high attrition, so those planes that did get through US defenses needed to be especially lethal – hence their suicidal "crash" tactics.

The special defensive problems these posed were illustrated by a 1945 report from TF-58: "These attacks were generally by single or few aircraft making their approaches with radical changes in course and altitude, dispersing when intercepted and using cloud cover to every advantage. They tailed our friendlies home, used decoy planes, and came in at any altitude or on the water. Only once did the enemy attack in the old orthodox fashion [when] a raid of 32 Bettys with 16 fighters as cover stacked 14–18,000ft was annihilated 60 miles from this force."

TF-38's first rest period after Leyte Gulf (late November 1944) was used to practice new anti-kamikaze techniques developed by Vice Adm McCain's staff, particularly Cdr "Jimmy" Thach. A series of defensive exercises, codenamed "Moosetrap," was developed to practice fleet tactics, with designated US fighters flying kamikaze-style approaches. Specialized radar pickets were also developed. "Watchdogs" were radar picket destroyers deployed astride the most likely axis of inbound Japanese strikes, while "Tomcats" were deployed partially offset from the most direct route back to US carriers for a returning US strike force (see Plate H). Watchdogs and

Tomcats took station at sunrise, to patrol assigned 5,000–yard radius circles at 15 knots. Fighter direction teams were attached to each assigned destroyer.

Radar picket duty was extremely hazardous. Constant visual and radar searches were maintained, AA weapons were always ready, and all "bogeys" within 12,000 yards were fired upon. The picket destroyers monitored nine radio channels and reported all contacts to the flagship. Off Okinawa, picket destroyers were sometimes escorted by a second destroyer and/or AA-armed LCS and LCI landing craft. Although a Radar Picket CAP (RAPCAP) of at least four fighters was maintained over each picket throughout the day, a destroyer's main AA defense was still its own armament. At sunset the radar pickets would return to the protection of the Task Groups.

Returning US strikes first flew to the Tomcat picket, where they would circle the destroyer while the Tomcat's RAPCAP inspected ("de-loused") them for any Japanese aircraft trying to sneak into the US formation and follow them to the carriers. Once satisfied that the US return strike was clean, the Tomcat would direct them to continue to their carriers.

As US carriers recovered their day CAPs at dusk, individual Japanese torpedo planes learned to sneak in below radar behind them. Countering them was Thach's "Jack patrol" comprising "two to four fighters flying at low altitude in each of the four quadrants" at dusk, fanning out towards likely attack vectors, and visually searching the horizon for low-flying enemies invisible to radar and overhead CAPs. "No-fly zones" were designated sectors where any aircraft that appeared were attacked immediately.

Carrier damage control

Carriers are essentially floating fuel dumps and munition magazines. US carriers' "strength deck" was not the flight deck but the hangar deck, which in the *Essex* class was armored against 1,000lb bombs. US fast carriers were additionally armored against 6-inch (light cruiser) gunfire, and the Essex class also employed a dedicated torpedo defense system. Improved designs, tactics, damage control measures, and defensive power meant that after 1942 only one fast carrier was lost – the light carrier *Princeton* (CVL-23), to a 550lb bomb on October 24, 1944. However, several large carriers were grievously damaged in 1945, including CV-13 *Franklin* and CV-17 *Bunker Hill*. While torpedoes were most likely to sink a carrier (CV-2 *Lexington*, CV-5 *Yorktown*, CV-7 *Wasp*, and CV-8 *Hornet*, all in 1942), fires started by bombs and kamikazes proved deadliest to their crews. All hands were trained in damage control at schools ashore, and were constantly drilled while at sea.

Essex-class carriers were designed with a main cylindrical avgas tank, surrounded by a second "saddle tank," and then a third tank saddled around the second. As gasoline was pumped from the tanks it was replaced from below with seawater, so gasoline and air were never in the tank together; the influx of seawater kept pressure sufficient to continue pumping gasoline from above it. Avgas was depleted from the top saddle tank first, thus progressively surrounding the inner tank with water. The pipes and pumps were consolidated into a vertical armored trunk that could be flooded with inert carbon dioxide. When aircraft fueling was finished, the avgas remaining in the hoses and pipes was sucked back into the tank by pumping some of the seawater out. Any gasoline spilled aboard was immediately swabbed up.

Foamite systems were installed every hundred feet on the flight deck. Foam, water "fog," and seawater could be pumped through firehoses on the flight deck or in the hangar. Fog-nozzle sprinklers were installed

USS *Ticonderoga* (CV-14) listing to port on January 21, 1945, after a *kamikaze* hit. Because Essexes listed outboard when turning, captains were instructed to put a burning Essex into a tight starboard turn, so carrying flaming gasoline to port and away from the island, hangar conflagration stations, flight deck repair lockers, and machinery main intakes, which were all located on the starboard side. Some hundred officers and men were killed or wounded by this attack, including the *Ticonderoga*'s Capt Kiefer. After repairs in the United States, CV-14 nevertheless rejoined the Fast Carrier Task Force on May 22. (NARA via Mighty90)

in hangar overheads, while doors could partition the hangar into bays for divide-and-conquer firefighting tactics. All hangar bays contained a conflagration station – an airtight cubicle with thick glass ports from which hangar firefighting could be remotely controlled. Magazines could also be sprinkled or flooded. The Essex class employed 14 ship-powered fire mains, with two more powered by portable gasoline engines, and mobile gasoline-powered 500lb pumps were also employed.

A carrier could be conned from five different locations, including the steering engine room. If a hit to the bridge incapacitated the captain, the XO took command at secondary ship control from his Battle Two station. Engine commands could be given via battle phone circuits, sound power phones, ship's service phones, the general announcing system, and the steering telegraph. Each carrier was assigned one cruiser to come alongside and assist with fire hoses and repair parties. If the carrier was crippled, a second cruiser would take it in tow while four destroyers were assigned for escort.

F

DIVE-BOMBING TACTICS

These schematics illustrate a final attack run by an 18-plane US dive-bomber squadron onto its target – here, a Japanese cruiser – in plan (left) and elevation (right); **key numbers** apply to both.

(1) In selecting his squadron's initial approach at 20,000ft, the commander has considered wind conditions, possible sun or cloud concealment, time issues, the base course of the target, its screen's disposition, aerial opposition encountered or expected, and the general tactical situation. After making visual contact with the target he employs the "standard final approach," losing altitude to 15,000–12,000ft in a shallow high-speed dive.

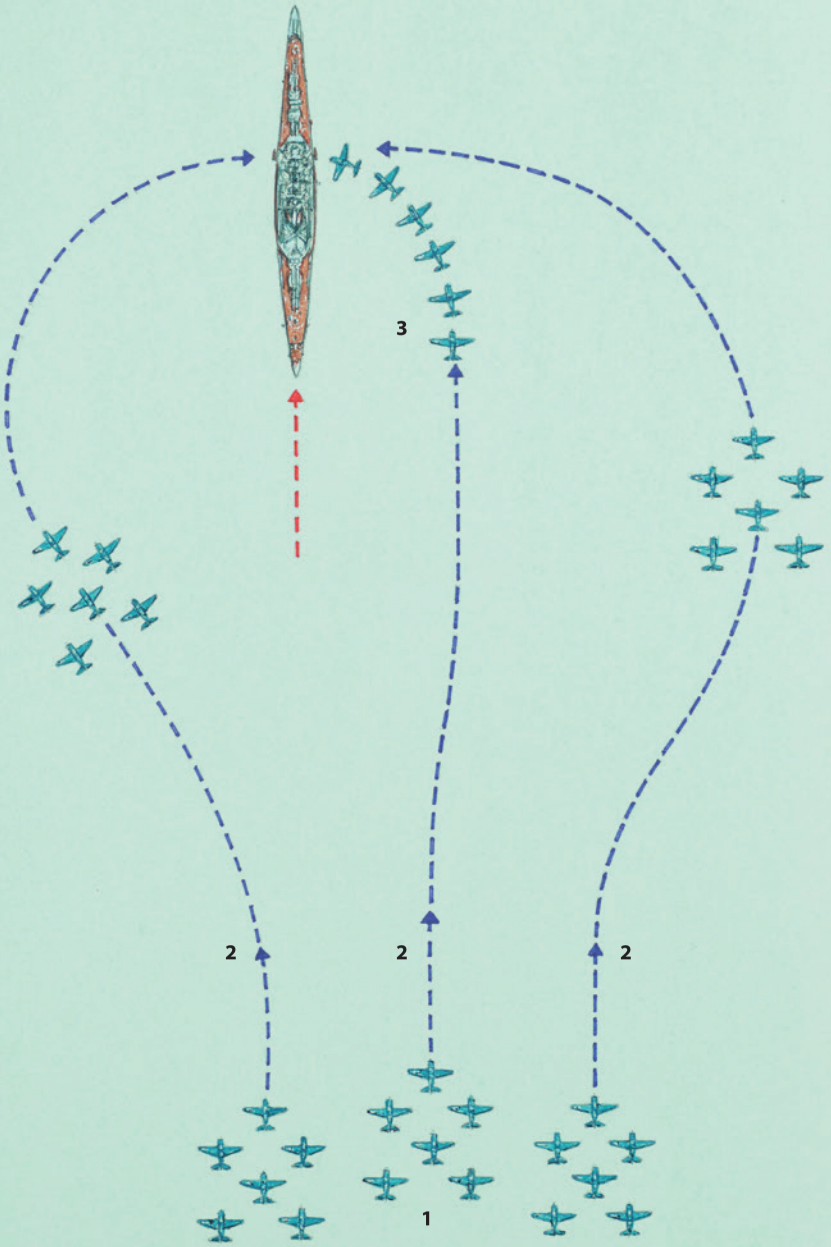
(2) Around 10 miles out, the 6-plane divisions separate, approaching the target from left, straight ahead, and right, while each maintains its defensive formation.

(3) About 5 miles from the target, the lead 6-plane division changes into single-file column for its dive, with an approximate distance of 400ft between planes, and succeeding planes stepped down slightly. Meanwhile the two trailing divisions are still in tight, mutually-supporting formations; it is at this stage that enemy fighters can most be expected. The divisions will attack one after the other at short intervals. The actual moment of abandoning the tight defensive formation for the dive in open column depended on AA fire, any fighter opposition, and how weather and light conditions affected visibility. A bomber committed to its dive was a difficult target for both fighters and AA gunners.

(4) Entry into the steep final dive began at no lower than 12,000ft, at a lateral range of about ¾ to ½ a mile from the target. A smooth and gradual pushover into the 70-degree dive by the squadron commander was essential, and dive brakes were lowered to achieve a speed of about 275mph. Each pilot needed to anticipate horizontal deflection to allow for the target's forward movement, and if he pushed over into his dive too soon the angle would become progressively flatter, which was undesirable. Allowing a proper lead would see the target drift into the bombsight by the desired point of release.

(5) Bombs were released at between 2,000 and 1,000ft; release below 1,000ft would require recovery from the dive at below 700ft, putting the Helldiver in danger from the blast of its own bomb.

(6) After recovery, the dive-bomber sped away at low altitude.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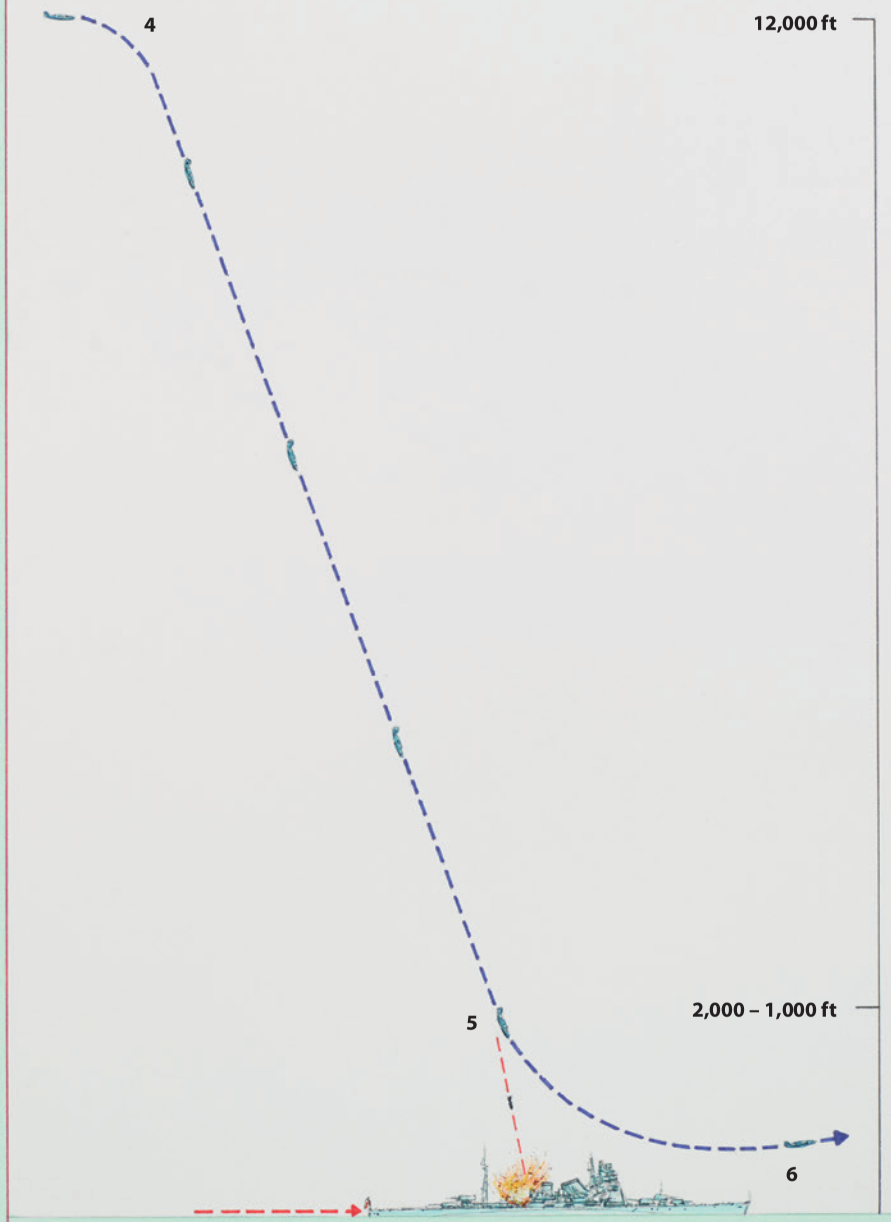
12,000 ft
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2,000 – 1,000 ft
5
6

Fast battleships of Adm Mitscher's Task Force 58 underway in 1944. During Operation "Hailstone" on February 17, 1944 TF-58 air strikes crippled Japanese warships fleeing from Truk, but then were called off to allow the fast battleships *Iowa* and *New Jersey* to make the kills. Admiral Spruance's morale-boosting battleship sweep sank the IJN light cruiser *Katori*, destroyer *Maikaze*, and minesweeper *Shonan Maru*, but in truth it was more an uncharacteristically reckless joyride than a particularly efficient use of TF-58's surface and air assets. A better combined-arms operation – of the type that modern historians seem almost to have forgotten – was "Gratitude" on January 12, 1945, when a Light Surface Striking Force was detached to shell Cam Ranh Bay, French Indochina, at the same time as TF-38 carried out airstrikes. (Getty Images 101924621)

SURFACE COMBAT

Although the sheer long-range ship-killing power projected by US fast carriers by 1944 made daylight surface battles increasingly unlikely, US battleships' subordination to aircraft carriers was never as clear-cut as commentators may suggest. The 1944 *War Instructions* still went into its greatest detail when addressing the "major action" – an apocalyptic battleship-led fleet action – and both the USN and IJN anticipated surface actions in the presence of fast carriers. Doctrinal flexibility allowed the Fast Carrier Task Force to tailor units to meet various threats; for example, the FCTF could employ "minor action" tactics to intercept "Tokyo Express"-type runs (nighttime resupply/reinforcement of Japanese-held islands by IJN warships) by detaching an independent Light Surface Striking Force of light cruisers and destroyers.

The ultimate US scenario (which Spruance, Mitscher, and Halsey all repeatedly tried, and failed, to achieve) saw the full IJN battle fleet under simultaneous bombardment by the fast battleships' 16-inch batteries and the fast carriers' air strikes. Because placing carriers within enemy gun range was unthinkable, a "major action" demanded that the fast battleships and assigned escorts from within the carriers' screens be drawn out from the existing carrier Task Groups into a newly-constituted, forward-deployed, battleship-centered Task Group, called the Heavy Surface Striking Force. Unleashing the fast battleships to forge ahead of the fast carriers in pursuit of a surface fight therefore required exquisite timing and seamanship. Accepted tactical doctrine, which Halsey controversially dismissed at Leyte Gulf, was to detach the fast battleships accompanied by a single fast carrier Task Group to provide air support.

If a major surface battle appeared imminent, tactical command would pass from the fast carriers to the fast battleships. The battleships would deploy into battle line ahead of the carriers, and fast-firing light cruisers and torpedo-armed destroyers would assemble ahead and astern of the battleships to mount independent attacks on the IJN battle line. The US fast carriers, auxiliaries, and a minimal screen would remain 15–20nm behind the US battle line; having sought out and destroyed any extant IJN carriers to establish air supremacy, US carriers would then support the battle line's action by launching airstrikes against the IJN fleet 30nm ahead (just beyond IJN gun range). US heavy cruisers would surround the fast carriers abeam and astern, fending off any IJN flanking attempts with their long-ranged, radar-directed 8-inch guns. After the expected US victory, continuing carrier

strikes would further cripple fleeing IJN remnants while US surface assets completed the IJN's annihilation.

In anticipating this scenario in late 1944, senior US surface officers may have failed to comprehend both the overwhelming power of US carriers and the utterly defeated state of the IJN. As late as February 1945, Spruance loaded TF-58's fast battleships with 80 percent AP shells in anticipation of a battleship duel off Japan. On April 7, 1945, six old US battleships sortied against the approaching *Yamato,* but were outrun to their target by TF-58 airstrikes. The US carriers' ability to strike from 200nm-plus instead of the 10–15nm of surface ships made traditional flanking movements by enemy surface forces virtually impossible.

The Fast Carrier Task Force ultimately never saw a major surface battle. The two great opportunities were squandered – first by Spruance's caution at the Philippine Sea (June 19, 1944), and then by Halsey's carelessness at Leyte Gulf (October 25, 1944), where the fast battleships missed multiple opportunities for surface battles against two widely-separated IJN fleets inside 24 hours. At both the Philippine Sea and Leyte Gulf, Mitscher and his carrier admirals desired an aggressive night-time battleship surface action. However, by June 1944 the fast battleships' unceasing AA duties had already permanently dispersed them throughout TF-58. They had never assembled or trained as a single unit; fast battleships commander Vice Adm Willis Lee hadn't even met all his battleship captains, and was wary of conducting a radar-directed nighttime battle-line action without sufficient training.

AIR COMBAT

The basic USN manual outlining late-war carrier air combat was the November 1944 *USF-74B: Current Tactical Orders and Doctrine U.S. Fleet Aircraft, Volume One, Carrier Aircraft*. Various CAG and squadron commanders also developed their own supplementary tactics, and, when proven successful, these "custom-made" tactics were diffused throughout the carrier force via reports and circulars.

Scouting

By 1943, ad hoc reconnaissance began replacing dedicated Dauntless scouting squadrons. Flying in sections of two to three planes for mutual support, scouts typically searched "pie-slices" of the compass extending up to 350nm out from the Task Group. Visual search altitude was 500–1,000ft, while the Avengers' airborne radar functioned best between 1,000 and 3,000ft altitude. A large convoy could be radar-detected at 30–40nm, a cruiser at 25–35nm, a destroyer at 15–20nm, and on down to a submarine periscope at 1–3 miles. Airborne radar could detect a multi-engine aircraft formation 10–15nm out and single-engine formations 6–8nm out. By mid-1944 the Fast Carrier Task Force could increasingly rely on long-range land-based planes for scouting. Though neither administratively nor tactically subordinated to the FCTF, forward-deployed submarines also stalked approaching enemy formations and radioed contact reports.

Strikes

Offensive projection of massed airpower was the fast carriers' purpose. A **sweep** was an all-fighter raid that sought and destroyed enemy aircraft or targets of opportunity (typically, airfields) in a designated area. A **strike** entailed bombers and fighters attacking specific, predesignated targets.

This June 1942 view of the Yorktown-class carrier USS *Hornet* (CV-8) reveals operational details. The landed air group has been pushed forward to the "Fly One" area at the bow, clearing "Fly Three" aft for landing operations. The crash barrier is visible amidships, and a landed aircraft on the stern; note too the trailing "plane guard" destroyer. The sea indicates that *Hornet* is steaming into the wind. This photo is a still frame from legendary director John Ford's 1942 documentary *The Battle of Midway*. (Getty Images)

Days before a planned strike, photo-reconnaissance flights would record the locations of targets and AA batteries (each photo flight comprised one camera-equipped fighter and one fighter escort). By 1945 a flak intelligence officer briefed pilots on AA gun locations and recommended inbound and outbound routes. Strikes against land targets, invariably preceded by fighter sweeps, were launched 60–70nm from the coast. This range kept continuous strikes over the target, but put the Task Force in serious danger of counterattack. Strike ranges against naval targets were affected by many variables but were typically limited to 200–250nm, although ranges could be stretched if the target warranted such a risk. A long-range strike mission might last four hours, and ideally all aircraft would be recovered by sunset. Contrary to Philippine Sea legend, US carriers always illuminated for returning pilots regardless of the enemy threat. If tactical situations prohibited lighting carriers, late afternoon strikes would simply not be made.

By 1944 at least 60 percent of a carrier's fighter complement was expected to accompany a full strike; experience revealed that fighters defended a carrier most efficiently not through large CAPs but by ensuring the success of offensive strikes. The minimum acceptable escort for a strike of any size (even one bomber) was 16 fighters. Each bomber division (6 bombers) was assigned a specific fighter division (4 fighters) as escort.

Each tactical division rendezvoused immediately after takeoff. When an "urgent attack" was ordered, half the escorting fighters launched first and each airborne bomber division proceeded towards the target immediately, effecting a running rendezvous en route, with the first division always accompanied by fighters. A "normal attack" saw all elements rendezvous expeditiously in the vicinity of the carrier and depart without further orders. In a "deferred attack," all attack groups rendezvoused and proceeded as a single group. A "search attack" was used when the target's location was only approximately known; search units launched first under urgent departure. The attack group followed along the general flight path, circling at two-thirds the estimated distance to the target and awaiting a contact report before attacking.

Once aloft, a well-trained CAG could assemble in 20 minutes before departing for the target. A Task Group's carriers would launch its CAGs simultaneously; they would proceed within tactical-support range of each other, but striking separately. Light carrier CAGs would come under a large carrier's CAG commander, both outbound and during the attack. Each Task Group designated a CAG commander to be overall "target coordinator," commanding all of that group's CAGs during the attack. The target coordinator remained on station in between strikes, under fighter escort.

Dauntlesses and Helldivers mounted twin flexibly attached Browning .30-cal M1919A2 air-cooled machine guns for defense, while Avengers carried a dorsal .50-cal M2 and a ventral .30-cal M1919A2. Dispositions of bombers in an attack group ensured that all flexible guns were uncovered throughout their defensive arc, with all planes within mutual supporting distance. An isolated two- or three-plane section under fighter attack were to move abreast of each other at 200-yard intervals so that gunners could cover each other's tails, and side attacks were to be countered by weaving (see below). Four bombers under attack were to form a diamond, while five were to form a tight V stepped down on either side. Altitude was to be traded for speed.

By 1945, 18-inch tinfoil/paper strips called "window" could be used to jam radars by shoving bundles of it out of turret vents. The simplest and most effective counter to AA fire was to vary altitude, range, and course unpredictably, although excessively violent maneuvers killed airspeed and were to be avoided. Small compact divisions were harder to hit than large formations strung out in echelon. No two planes in a bombing or strafing attack were to follow the same glide path, especially when descending through isolated holes in overcast. Aggressive strafing attacks by friendly fighters provided the best defense against automatic AA weapons.

The skipper of Carrier Air Group 15 aboard USS *Essex* (CV-9), Cdr David McCampbell, is photographed in his F6F-3 Hellcat "Minsi III" adorned with 30 Japanese kill flags. McCampbell would be the US Navy's leading ace of the war, credited with 34 confirmed aerial victories; these included 7 in one day on June 19, 1944 and 9 on October 24. McCampbell was one of the first CAG commanders to fly a fighter instead of a bomber, but by 1945 almost all others were following suit; their fighters were specially equipped with two radios for improved communication with the air group (Getty Images)

Fighter tactics

The fighter squadron's primary mission was defense of its own forces, either through combat air patrols or combat escort of strikes. Fighters' secondary mission was to operate offensively in attacking enemy air, surface, and shore forces via fighter sweeps, intruder missions, bombing, and rocket attacks.

In July 1941, USN fighter squadrons were reorganized into divisions of four fighters comprising two two-plane sections. This was considered the optimum fighter combat team, and fighters were to be added to missions only in whole four-plane divisions.

In aerial combat both high speed and high altitude were to be maintained as much as possible, though one could be traded for the other. The USN stressed air-to-air gunnery training, and especially emphasized deflection shooting – that is, shooting from an angle that required "leading" the target (in Cdr Jimmy Flatley's words, "You must shoot at a spot out in space that will be full of airplane when the bullets get there.") Expert deflection-shooting skill increased USN fighter pilots' lethality by allowing attacks from unexpected angles, which also minimized return fire. USN fighters employed the electric Mark 8 reflector gunsight, which helped calculate deflection and kept the target centered by projecting an illuminated reticle out to infinity. Ideal air-to-air gunnery range was 100–200 yards, with

An aviation rating manning the rear twin .30cal Browning machine guns of an SBD Dauntless dive-bomber aboard USS *Independence* (CVL-22) on April 30, 1943. Enlisted gunners received nine months' training, including boot camp, and were qualified in both air-to-air gunnery and radio operation. SBDs were removed from the Independence-class carriers by early 1944. (Wikimedia)

400 yards the maximum. Firing at closer than 50 yards risked collision with the target.

High-speed diving attacks from at least a 2,000ft altitude advantage were desirable; energy gained from the dive allowed a fast break away after the firing pass, and turning fights were to be avoided. The USN fighters' basic offensive tactic was "bracketing" – placing sections or divisions above and ahead on the bows of the target, so that any time the target turned it would give a favorable run to the fighters toward which it turned. If the target pursued a straight course, the sections were to make simultaneous runs from each bow position. Bracketing sections were to keep abeam of one another and make simultaneous runs in order to defend each other during all phases of attack and recovery. In 1941, VF-3's LtCdr "Jimmy" Thach developed the beam defense or "Thach weave" to counter the Zero's reportedly superior performance to the F4F Wildcat (see Plate E). First executed extremely effectively at Midway, this was employed religiously throughout the war, both by individual pilots and entire fighter divisions.

Fighter escort tactics were adapted from Thach's beam defense, with fighter divisions flanking the strike and constantly weaving to maintain all-around observation. As additional escort fighter divisions were added to a strike, they assumed positions of increasing lateral separation from and altitude above the escorted strike. In 1944 the recommended minimum escort for a strike was 16 fighters for up to 18 bombers, 24 fighters for 36 bombers, 48 fighters for 72 bombers, and 96 fighters for 144 bombers.

Fighters were instructed to maintain "superiority of position" (that is, superior altitude over enemy aircraft) and the "interior position" (staying between the enemy and his objective or his route of retreat). *USF-74B* stated emphatically that "Above all, it has been learned that fighters must *stay together*... and be in position to support or be supported. Each plane is part of an invisible chain. Any plane which breaks the chain by diving away, either to avoid an enemy or in pursuit of a target, subtracts from the overall strength of the group." Leading USN ace Cdr David McCampbell (34 kills) urged his pilots not to follow smoking enemy aircraft down to confirm a kill, as this cost priceless altitude and broke up the formation. He had his Hellcat pilots calibrate their six .50-cal machine guns for a 3–foot circle at 1,000ft for the most concentrated fire. Japanese aircraft were unarmored and lacked self-sealing fuel-tanks: "We learned very early that if you hit them near the wing roots, where the fuel was, they would explode right in your face."

Strafing and rocket attacks

Fighters not assigned to the escort group were expected to strafe targets ahead of attacks. *USF-74B* noted that "Fighter strafing attacks have a most devastating and demoralizing effect on both ships and shore installations.... Strafing attacks should support bombing and torpedo plane attacks, generally using fighters not assigned as escort for bombers. The strafing attack should immediately precede the main attack and should be concentrated on screening vessels if they oppose the main attack. Otherwise they should be directed against the main objective."

Replacing the SBD Dauntless, the SB2C Helldiver was the official Fast Carrier Task Force dive-bomber by 1944, but by 1945 the Corsair fighter-bomber was proving categorically better in this role. Note the tricolor camouflage scheme of sea-blue top surfaces above intermediate blue-gray sides, with white undersides; bombers retained this scheme until October 1944, whereas fighters changed to glossy sea-blue on all top and side surfaces from that March. Initially plagued by technical problems, the SB2C was not universally popular with its crews, and its designation was said by some to stand for "Son-of-a-Bitch 2nd Class." Nevertheless, it sank more Japanese tonnage than any other aircraft type. (World War II Database)

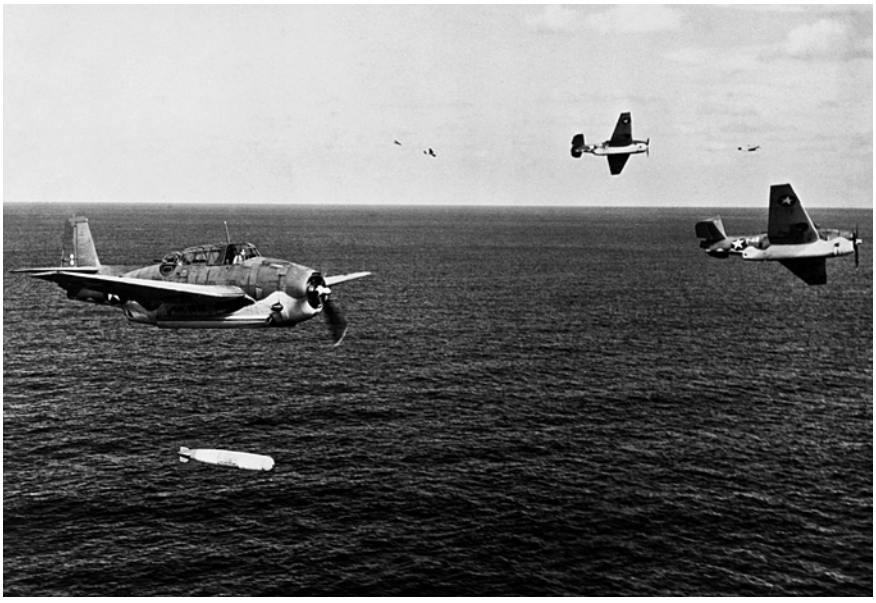
Strafing attacks could silence exposed gun positions, disable destroyers, cause irreparable damage to radio and radar installations and ammunition dumps, and were considered the "most positive method of destroying" grounded aircraft. Against heavily defended targets, the strafing fighter began pulling out at 1,500ft, bottoming out at 700–800ft altitude. Fighter sweeps against airfields were a primary mission, often augmented by rockets. A fighter sweep would divide into vertically-stacked elements, with the lowest element strafing and rocketing the airfield while covered by the higher elements. Once an element had strafed a field it would depart for the next targeted field, and each cover element would step down one level and repeat the process. After 20 minutes without enemy fighter interference, the final original high cover element would strafe the field without cover, then report the target's condition to the next incoming fighter sweep. Admittedly, when strafing parked aircraft it was difficult to ascertain whether the target was destroyed, or how many times separate strafers had counted the same target as a kill.

To keep Philippines airfields smothered from dawn though dusk during strike operations, Thach developed a three-strike system nicknamed the "Big Blue Blanket." Individual carriers of TF-38 launched their own strikes in three smaller waves rather than the standard two deck-load waves, the three waves coalescing over the target – up to 1,000 aircraft in total. Day Target Combat Air Patrols were assigned specific airfields to smother, with individual strikes often broken up to cover multiple airfields, leaving them uncovered for only ten minutes between strikes. The brief gaps at dusk were solved by night carriers in the form of "zipper" twilight sweeps, while "hecklers" kept defenders awake at night.

Rocket-powered ordnance was a mid-war development. Hellcats carried six rockets each, while Corsairs, Helldivers, and Avengers carried eight. Attacks began with a 20–35 degree dive from 4,500ft altitude. Rockets were fired from 1,500–1,000ft altitude, and pull-up was at 1,000–800ft. Rocket attacks required greater marksmanship than machine guns because ranging rounds could not be "walked onto" the target.

The 1,045mph 3.5-inch Forward Firing Aircraft Rocket (FFAR) was first used in combat in January 1944, proving useful against submarines, although

A division of Grumman TBF Avengers executes a practice torpedo run – compare with Plate G. In 1943 the California Institute of Technology began an intensive study to improve the disappointing performance of the Avengers' air-dropped Mark 13 torpedo, which included 4,300 air-drop tests. Among many issues, it was discovered that the prescribed "low-and-slow" approach (seen here) actually damaged the Mark 13 by causing a flat, slapping impact. By late 1944 improved methods and modifications allowed a much higher and faster torpedo run, improving weapon performance and aircraft survival rates. (Getty Images 615312280)



its warhead was too small for hardened targets. The heavier warhead of the subsequent 5-inch FFAR halved its velocity, but the improved 5-inch High Velocity Aircraft Rocket (HVAR) or "Holy Moses," with a velocity of 935mph, was the most successful rocket of the war**.** A Corsair carrying a full load of eight HVARs equaled a destroyer broadside in firepower. The Holy Moses entered combat in August 1944 and proved highly effective, even sinking one Japanese destroyer.

The 10.5ft-long, 11.75-inch Tiny Tim rocket was introduced in 1944 as a powerful anti-shipping weapon that could outrange AA fire; it delivered a semi-armor piercing 148.5-lb HE warhead from a maximum

G

TORPEDO-BOMBING TACTICS

The "anvil" attack

These schematics illustrate an attack run by a 12-plane US torpedo-bomber squadron onto its target – here, a Japanese battleship; **key numbers** refer to both the plan (left) and oblique (right) views.

The ideal attack saw torpedoes being dropped off both bows of the target and as near to simultaneously as possible – the so-called "anvil attack." If properly executed, this meant that any maneuver by the target would still leave it broadside-on to some of the torpedoes, thus preventing a skillful Japanese captain from paralleling torpedo tracks and "combing" between them. Bow approaches by the bombers also minimized exposure to anti-aircraft fire, by reducing both the closing range and dropping range. At least six Avengers were assigned to each carrier or battleship target, but more than 12 was considered inefficient.

(1) In low visibility, attacks could be initiated from any distance and altitude, but in normal conditions the approach was at between 20,000 and 10,000ft altitude.

(2) Radical changes of speed or course by the target ship were to be expected; Japanese warships frequently entered high-speed turns through 360 degrees or even circled through 720 degrees. Maintaining altitude until the final attack run allowed the Avengers to observe the targets' movements and to respond at high speed (285–345mph), to reach a favorable bow-on attack position.

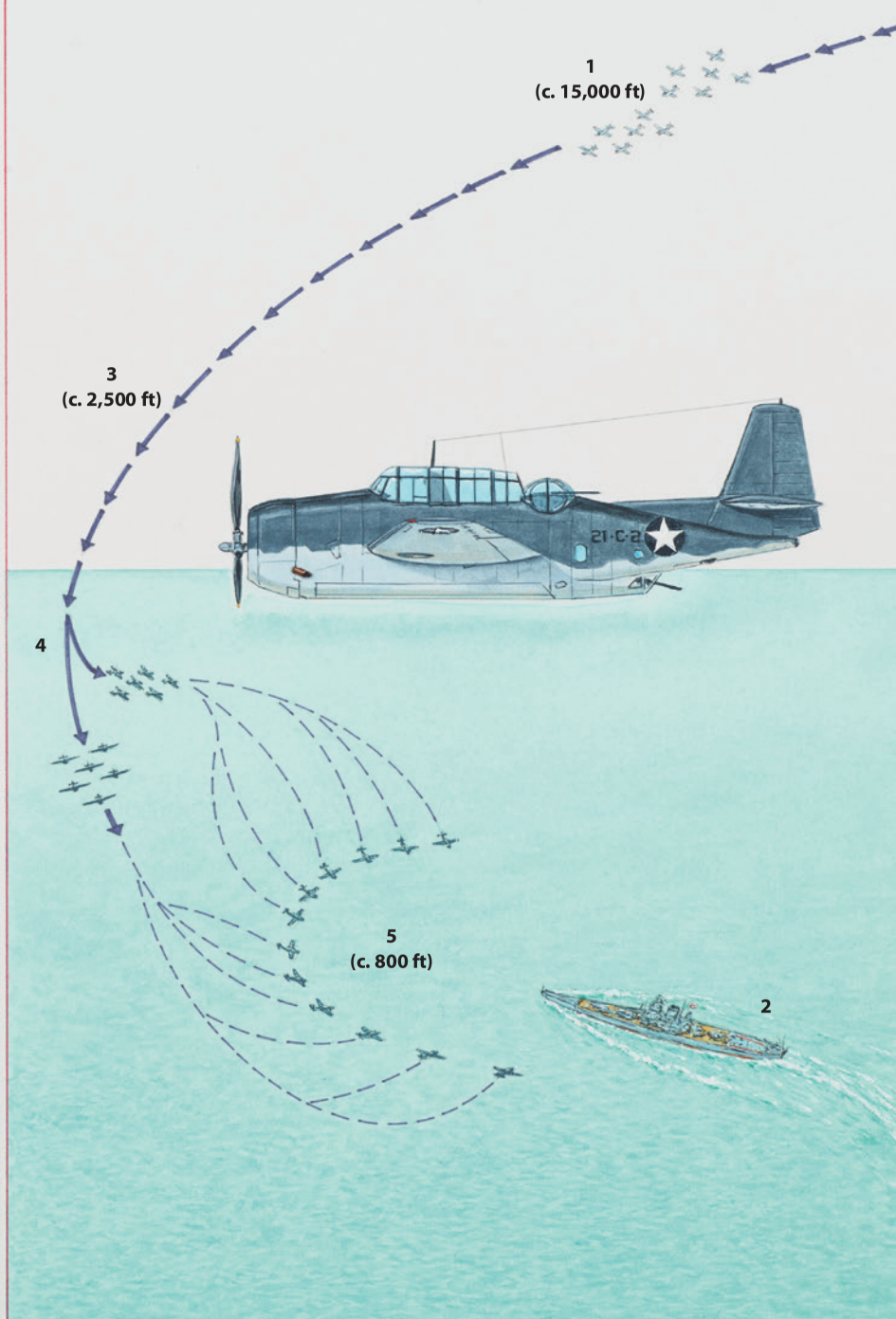
(3) The target's destroyer screen was to be crossed at 3,000–2,000ft altitude.

(4) Divisions would then separate to take up positions on the target's bows, with the leader taking the far bow. Early dissipation of altitude and speed was to be avoided. Ideally, attacks were made after the dive-bombers' bombs began impacting (see Plate D).

(5) The Avengers attacked roughly in line abreast, and torpedoes were dropped at 800ft altitude and 4,200 yards from the target, at a speed of about 300mph. The time between the arrivals of individual torpedoes at the target was to be as short as possible. After dropping, each pilot was to continue across the target's bow or to turn and parallel it in the opposite direction when outbound.

(Inset) TBF-1 Avenger of VC-22, embarked on the USS *Independence* (CVL-22), October–November 1943. Normally embarked on escorts carriers, composite squadrons (VC) of mixed aircraft types were sometimes deployed on light carriers, at least in 1943.

3
(c. 2,500 ft)
4
5
(c. 800 ft)
2
1
(c. 15,000 ft)


1
(c. 15,000 ft)
3
(c. 2,500 ft)
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(c. 800 ft)
2

range of 1,600 yards. However, compared to the HVAR the Tiny Tim was clumsy and inaccurate. After the USS *Franklin* (CV-13) was knocked out of the war in March 1945 partly due to sympathetic detonation of Tiny Tims in her magazine, only *Intrepid* continued to carry them, and then only briefly.

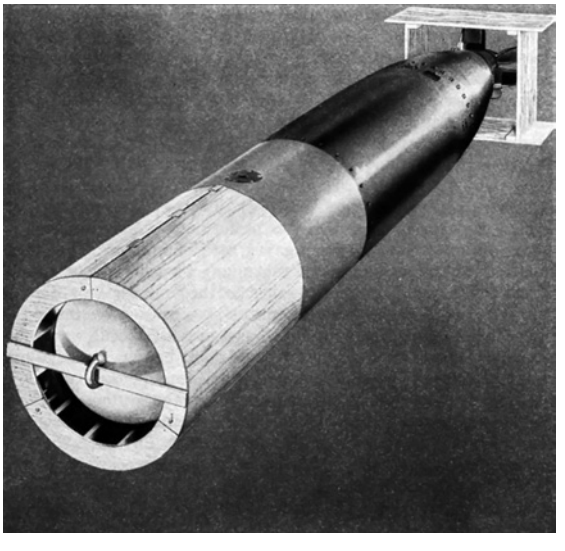
Bombing

Bombing squadrons performed the following strike missions: dive-bombing, glide-bombing, low-level bombing, radar low-level bombing (by night), and composite bombing (intermediate and high level). Their non-strike missions were spotting and observation, patrol (ASW and anti-torpedo plane), and smoke laying.

USF-74B stressed: "All enemy carriers must be put out of operation at the earliest practicable moment. The attack group should be of such strength and their fire so distributed that *all* enemy flight decks are damaged to the extent aircraft cannot be operated therefrom. If the attack is against a shore-based installation, enemy aircraft must be destroyed first and the fields rendered inoperable … Once the enemy's air power has been destroyed, concentration of sufficient strength to sink or completely disable individual vessels is desirable … the actual distribution will be dependent on the situation … it would be most unsound to concentrate 18 bombers on one carrier and to leave another untouched."

USN dive-bombers (see Plate F) made their approaches from 20,000–30,000ft altitude. The attack run began with a shallow descent 10nm from the target. Once a bombing group was within striking distance of the enemy, it was extremely difficult for enemy fighters to stop the attack unless they were in overwhelming numbers. It was essential that dive-bombers maintain a formation that could be readily closed up for defense, yet was also maneuverable. Between the approach and the final dive the leader would maneuver in easy turns to reduce the threat from AA fire, which in any case was considered very ineffective against dive-bombers. At an altitude of 12,000–15,000ft and lateral distance to target of three-quarters to one-half a mile, the dive-bombers reduced throttle, extended dive brakes, and pitched over into a 70-degree, 275mph dive which was to be pressed home regardless of opposition. *USF-74B* noted: "Should fighter opposition be met, close formation should be maintained until just before push-over … There is little to fear from fighters once the dive is started. [Use of air brakes causes] enemy fighters to overshoot so rapidly that effective gunnery is most difficult."

Once the attack was started it was never to be broken off; the first few bombs damaged enemy morale even if they missed. Planes in column were to maintain 400ft intervals, with succeeding planes stepping down slightly. Because most misses were errors in range, not deflection, dives on ships were preferably along the fore-and-aft axis rather than across the beam. Correcting range mid-dive was also much easier, while only slight mid-dive deflection corrections could be made without ruining the bomb run. Single-file attacks were



The Mark 13 air-dropped torpedo in its heavily-modified late 1944 configuration. The nose is covered with a plywood "pickle barrel" drag ring which slowed and stabilized the Mark 13 mid-drop and absorbed energy upon impact, thus protecting the torpedo's delicate machinery. The box-shaped shroud ring on the tail greatly reduced roll, oscillation, and broaches once the Mark 13 was in the water. An early 1945 test recorded that five out of six modified Mark 13s that were dropped from between 5,000 and 7,000ft altitude ran hot, true, and normal. (US Navy)

preferred over simultaneous section attacks; experience demonstrated that they produced a higher percentage of hits and were more difficult to defend against. The single-file attack produced a continuous rain of bombs at intervals of 2–8 seconds, presented enemy gunners with a confusing multiplicity of targets, and was considered more destructive to enemy morale. Bombs were released at 2,000–1,500ft, about 30–35 seconds after pushover, and impact was 3 seconds after release. Pull-out was to be gradual, with retirement made at high speed (gained from the dive) on divergent courses to avoid AA fire. No attempt was to be made to regain altitude.

A Grumman F6F-5N Hellcat night fighter armed with two 20mm cannon and fitted with an AN/APS-6 radar pod on its starboard wing, 1944–45. Night fighters were equipped with flame-dampeners on exhausts and flash-hiders on guns, which were loaded with one tracer in every 15 rounds. A total of 1,189 F6F-5N Hellcats had been built by the time production ended in late 1945. (Wikimedia)

Torpedo-bombers and fighter-bombers primarily employed glide-bombing, which involved a milder 45–55 degree descent. Glide-bombing was also used when the cloud ceiling was 6,000ft or lower, when there was a lack of time to regain altitude, when multiple dives were to be made on a target, when attacking submarines, or when night bombing. Air-brakes were not used; release was to be from 1,500ft, with pull-out at 1,000ft.

Low-altitude (level) bombing was for use "when the weather is unsuitable to permit dive or glide bombing but still some altitude may be obtained in the vicinity of the target." An example was if the target was under cloud cover but an adjacent area was clear, "in which case altitude may be gained for a glide down under the cloud cover, making a high-speed low-level run."

By 1944 the SBD-5 Dauntless could carry one 1,600lb bomb, while SB2C-4 Helldivers, TBM-3 Avengers, F6F-5 Hellcats, and F4U-1D Corsairs could carry two 1,000lb bombs simultaneously; the Helldiver could alternatively carry a single 2,000lb bomb. Bombs were typically GP (general purpose) or AP (armor piercing). A third important type was the depth bomb for ASW work. On March 30/31, 1944, TF-58 Avengers successfully blockaded Palau with air-dropped 1,048lb naval mines, but Mitscher disdained mining and largely abandoned the practice. A mid-1944 invention was napalm, a jellied gasoline dropped in disposable tanks. These tumbled inaccurately, but upon detonation produced a 25,000-square feet inferno that burned intensely for one minute, then smoldered for another 10–15 minutes. Napalm proved highly effective against enemy fortifications and personnel.

Torpedo attacks

The USN had long viewed carrier-based torpedo bombing with suspicion. Torpedoes were expensive, complex, and difficult to deliver, while only a fraction of their heavy weight was actual warhead. By the 1930s the USN was poised to abandon aerial torpedoes entirely (CV-4 *Ranger* was completed without a torpedo magazine), but ultimately retained a token torpedo squadron per carrier as insurance against battleships.

Long over-sea missions made attempts to recover aircrew who were forced to ditch or bail out particularly important. Here, off enemy-held Truk on May 1, 1944, an OS2U Kingfisher floatplane from USS *North Carolina* taxies across the lagoon, unable to take off with its load of no fewer than nine recovered airmen. This Kingfisher ultimately transferred her charges to the lifeguard submarine USS *Tang* (SS-306), but less-burdened floatplanes often took off under Japanese fire. The *Enterprise*'s Cdr William Martin reported that while Japanese flak usually fell behind carrier aircraft, the SOC Seagull that rescued him off Saipan was so slow that Japanese gunners led too far ahead. (Wikimedia)

Wartime TBF Avengers employed the Mark 13 Mod 1 torpedo, which had entered service in 1940. The 2,216-lb Mark 13 had a range of 6,300 yards at 33.5kts and delivered a 600lb Torpex warhead. Doctrine dictated that coordinated dive-bombing and fighter strafing should first eliminate a target's AA batteries, allowing the torpedo-bombers to methodically deliver their loads unmolested. In practice this proved completely unrealistic. In 1942 the Mark 13 could only be launched from 50ft at 125mph, and the complete failure and massacre of TBD Devastators at Midway proved that this was effectively suicide. For two years after Midway, USN aerial torpedo attacks were virtually suspended against well-defended targets (TF-58 expended just 12 torpedoes at the Philippine Sea). However, by late 1944, ad hoc stabilizers, shroud rings, and drag rings slowed the Mark 13 during its fall, allowing drops from 2,400ft at speeds of 270mph, and making aerial torpedo attacks against heavily-armed targets survivable. In the final year of the war, torpedo-bombers would sink Japan's super-battleships *Musashi* and *Yamato*. The Mark 13 ultimately achieved a 40 percent hit rate in 1,287 wartime attacks. (Torpedo hit rates against anchored or damaged ships were naturally much higher than against maneuvering ships.)

A torpedo attack against a well-defended target was invariably to be preceded by a dive-bombing attack (see Plate D). Torpedo planes were to approach the target from ahead; once the target was sighted, maximum speed was to be employed to reduce interference from enemy fighters. Screening ships were to be avoided; if a pilot could approach so as to always demand a deflection shot at high speed his chances of being hit by AA fire were small. Avengers typically dropped their torpedoes from 800ft altitude at 300mph, achieved by attacking in a shallow dive (see Plate G). The airborne torpedoes fell for seven seconds and traveled 3,000ft before striking the water, then needed another 1,200ft to arm. Torpedoes therefore had to be dropped at least 4,200ft from the expected point of detonation, and from drop to impact took 22 seconds. Torpedoes were to arrive at the target as simultaneously as possible, and this required excellent coordination and timing.

Night attacks and interception

Night and foul-weather air combat capability imparted obvious advantages. The fleet could be defended, targets of opportunity could be attacked, enemy airfields could be paralyzed by round-the-clock harassment, and day strikes could attack targets whose defending gunners had probably been awake all night. Night attacks were more difficult to counter with fighters or AA fire, meaning strikes could eschew tight defensive formations and could release ordnance closer to the target.

Night attacks were to be made by one or two four-plane divisions. To enhance natural moonlight, targets could be illuminated with parachute flares; primary targets could be directly illuminated (brighter than their surroundings) or silhouette-illuminated. A single plane would make repeated passes, releasing a succession of parachute flares from 1,800 feet altitude, slightly ahead and upwind of the target. Attacks could be made by radar-guided low-altitude bombing, flare-illuminated glide-bombing, or flare-illuminated torpedo-bombing.

Night-time interceptions against enemy aircraft were typically made by radar-equipped fighters, although it was possible for fighters lacking radar to achieve success in bright moonlight. Shipborne radar would direct night fighters to within a few miles of the "bogey," typically beneath and two miles astern of the target, both to facilitate detection by the fighter's radar and because visibility was typically better from below. One VHF channel was usually assigned per two-fighter section. Once radar contact was made, the night fighter completed the interception as rapidly as possible, reducing closing speed to 5–10mph when within half a mile of the target to avoid overshooting. It was possible to shoot on radar detection, but normally visual confirmation of the target was required, assisted by night binoculars and opening the cockpit hood for a clearer view.

Air-sea rescue

Strikes inevitably meant losing aircraft. The USN made the rescue of survivors a high priority; air-sea rescue saved valuable aircrew, and also

Crewmen of the submarine USS *Tang* (SS-306) pull downed US airmen out of their raft off Truk, May 1944; *Tang* eventually rescued 22 "zoomies", who were obliged to remain on the boat throughout her patrol. Pacific submarines commander Vice Adm Charles Lockwood described these operations to rescue aircrew as "no beer and skittles." The lifeguard submarines' most famous rescue was Avenger pilot Lt(JG) George H.W. Bush, from VT-51 on USS *San Jacinto* (CVL-30); the future 41st President was recovered by USS *Finback* (SS-230) after bailing out on August 1, 1944. (Wikimedia)

maintained morale and pilot aggressiveness. Admiral Mitscher explained, "You can train a combat pilot for $50,000. But never, ever tell a pilot that. We can't buy pilots with money ... his confidence [and] how hard he presses home the attack is exactly how effective we are. Such pilots are not cheap." When *Enterprise*'s Cdr William Martin was shot down off Saipan on June 13, 1944, his reported parachute was enough reason to direct the incoming strike not to bomb in the water. Hours later the battleships and cruisers bombarding Saipan were ordered that none of their shells were to fall short.

Aircrew downed during attacks on enemy-held islands instinctively used atolls' low coral reefs for cover from Japanese troops and boats, especially the deep outer edge usually hundreds of yards from the island. If far enough from enemy observation, an airman could inflate his life raft. Ad hoc flights would be sent from a carrier to scout for missing aircrew, and to defend them if necessary. A downed airman would signal the flight with a mirror or by any other means possible. Upon discovering aircrew in the water, the carrier planes would drop an additional life raft, which also reassured the airman that he had been seen.

Aerial search-and-rescue would be undertaken by a battleship's or cruiser's floatplane, which would land and pick up the airman as soon as possible. The floatplane pilot would shoot holes in the parachute and raft with his sidearm to sink it, ensuring that no more rescue flights would be sent needlessly. Harbor-based flying boats such as PBY Catalinas, and PB2Y Coronados (nicknamed "Dumbos"), also rescued downed airmen when range allowed.

Lifeguard submarines

The "Lifeguard League" was inaugurated during TF-15's September 1943 Marcus Island strikes. USS *Skate* (SS-305) made the first submarine rescues off Wake Island on October 7–8, 1943, saving six USN airmen. Thereafter,

H

TASK GROUP ANTI-AIRCRAFT DEFENSE TACTICS, 1944–45

By late 1944, increasingly sophisticated Task Group defensive tactics were required to counter the evolving Japanese air threat. These schematics, in elevation (above) and plan (below), represent a fast carrier Task Group deployed at the standard 70-mile range from an enemy-held coast (green), against which it has launched an air strike. The **key numbers** refer to both schematics.

(1) The full Task Group is 4–5 miles in diameter; the maximum range (pink) of its 5-in/38 anti-aircraft guns is 10 miles laterally and up to 37,000ft.

(2) Deployed 50 miles ahead of the Task Group are radar picket destroyers patrolling their stations.

(3) Above each picket is a dedicated RAPCAP (Radar Picket Combat Air Patrol – light blue) of at least four fighters patrolling at 15,000ft.

(4) Approaching the Task Group from the coast is an inbound Japanese air strike (red) at 20,000ft; this has been picked up on radar by the advance "Watchdog" picket destroyer **(2)** and reported back to the Task Group.

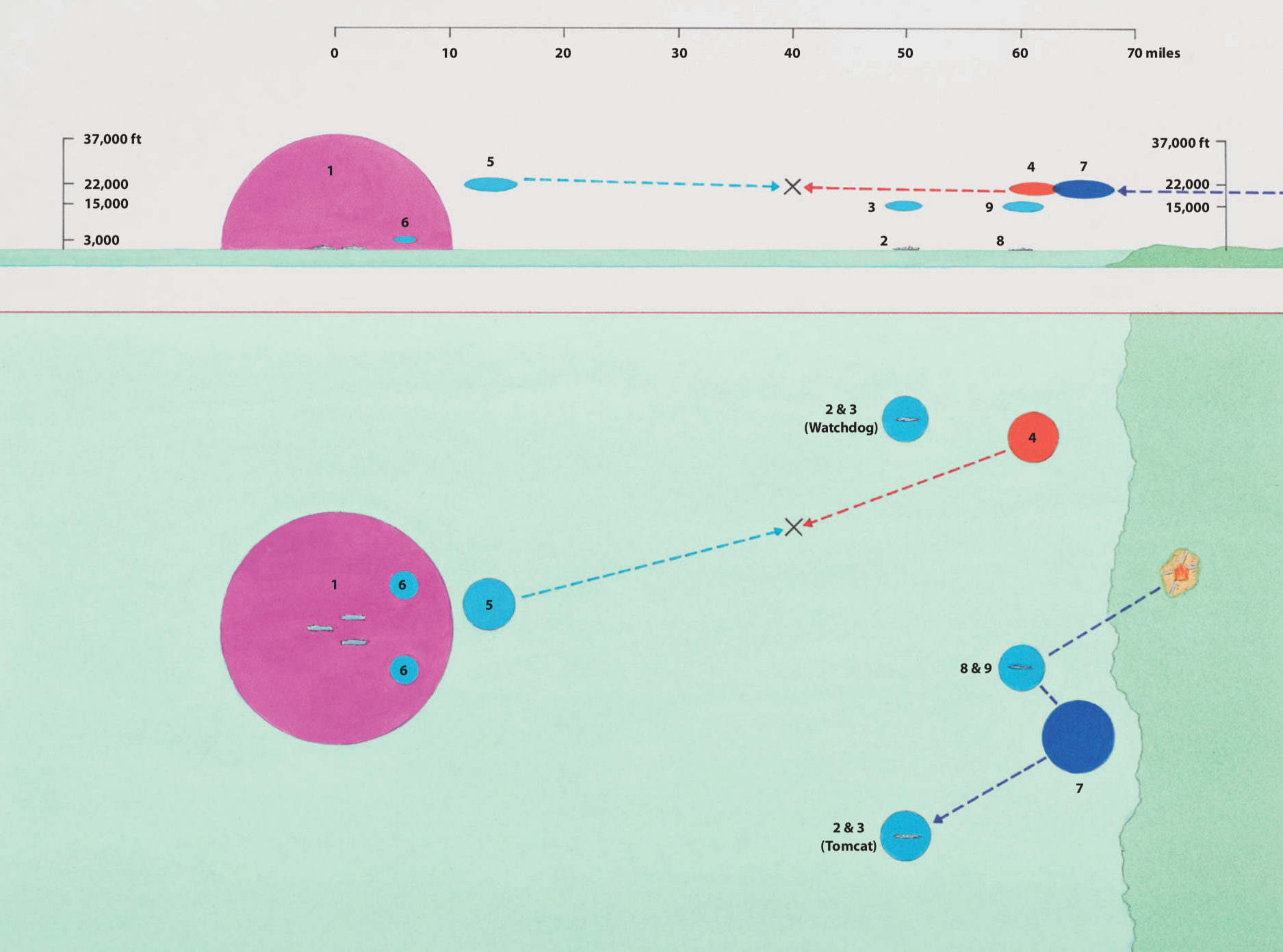
(5) The Task Group's main Combat Air Patrol (CAP – light blue), which was orbiting above it at 22,000ft, has been dispatched by the TG's fighter direction officer to intercept the threat as far from the Task Group as possible, calculated as at **(X)**.

(6) No more than 6 miles ahead of the Task Group's destroyer screen, and no higher than 3,000ft, the LOCAPs (Low Combat Air Patrols – light blue) remain under visual fighter direction from the destroyer screen. These fighters are tasked with identifying and shooting down any low-flying Japanese torpedo planes or *kamikazes* that get through.

(7) Meanwhile, the returning US air strike (dark blue) takes a pre-planned detour towards the "Tomcat" radar picket destroyer **(2)**, which is offset from the most direct route back to the Task Group.

(8) En route to Tomcat, the US air strike overflies the lifeguard submarine stationed offshore, ready to rescue any ditching aircrews. Above the boat its own combat air patrol **(9)** patrols at 15,000ft (SUBCAP – light blue).

Once the returning US strike reaches Tomcat, it circles overhead while it is checked by the RAPCAP for any Japanese aircraft trying to penetrate the Task Group's defenses by hiding among the returning US planes. Once it has been "de-loused," the US airstrike is released by Tomcat to return to its carriers. If, however, the Task Group is under Japanese attack, the picket destroyer might retain the returning US air group until the attack on the Task Group was resolved.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(Watchdog)
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8 & 9
7
2 & 3
(Tomcat)

Dressed for blustery weather, a Flight Deck Officer prepares to send a Helldiver of VB-84 (see Plate C) off the flight deck of USS *Bunker Hill* (CV-17) with a downward wave of his checkered flag. It is February 16, 1945, and the Helldiver is bound for Tokyo, where VB-84 would successfully bomb and rocket an aircraft factory the following day. The official order of priority for land targets in 1944–45 was: aircraft on the ground; ships and their repair facilities; fuel and ammo dumps; aircraft repair facilities and hangars; radio and radar installations; barracks and bivouac areas; transport equipment and workshops; AA installations; and finally, runways. (NARA via Mighty90)

surfaced lifeguard submarines, their pre-planned positions known to the airmen, would station just off a Japanese target scheduled to be attacked. Off Truk in April 1944, USS *Tang* (SS-306) called for close air support, ultimately rescuing 22 airmen. From then on, lifeguard submarines received "chickens"– their own fighter Combat Air Patrol (SUBCAP). Submerged submarines occasionally practiced the difficult and tedious art of "scoping"– rescuing airmen under Japanese fire by having the airman catch and then hang onto the moving periscope while the submarine dragged him out of range. By August 1945 lifeguard submarines had rescued 521 total Allied airmen, including 262 naval aviators.

Case study: Operation "Jamboree," February 16–17, 1945

US doctrine was to establish local air supremacy prior to any amphibious operation, which was accomplished by massive pre-emptive fast carrier strikes on Japanese airfields within range of the impending US landings. By the time of Operation "Detachment," the February 19, 1945 invasion of Iwo Jima, the airfields to be struck were in Tokyo itself. The fast carrier strikes against Tokyo were codenamed Operation "Jamboree" and scheduled for February 16–17.

Reinforcements and rotations meant that many of TF-58's air groups saw combat for the first time over Tokyo. Mitscher circulated a memorandum amongst his air groups, reminding aircrew of the fundamentals in which they had already been trained. Written by Mitscher's air operations officer Cdr Jimmy Flatley, the memo succinctly summed up basic USN strike doctrine as of February 1945, as follows.

Flatley recognized that Japanese fighter pilots, even though inexperienced, would be especially aggressive in protecting Tokyo. The better-trained Americans were reminded to exploit inferior Japanese pilot skill and overeagerness by keeping their mental composure, maintaining discipline, fighting as a team, and following well-established doctrine.

Rocket-armed US fighter sweeps would first wear down Japanese fighter strength, then dive-bombers and torpedo-bombers would launch to bomb Japanese ground targets. Fighter pilots were reminded that "your plane is superior to the Jap's in every way. He is probably more afraid of you than you are of him." Fighters were to engage aggressively, "falling back on your defensive tactics only if caught at a disadvantage."

It was acknowledged that the Japanese were aware of the "Thach weave," but the tactic still worked when performed carefully and in an unexpected manner, such as a more random pattern. If many Japanese fighters massed behind and above, American pilots were to "wait until they commit themselves to an attack. Then instead of weaving in 90 degree turns, go around 180 or 360. This will completely throw them off." Upon first sighting the enemy, fighter pilots were expected to "resist the impulse to follow your first individual reaction." Fighter team leaders were to fight their team according to plan. Section leaders were to work in unison with their respective team leader, and wingmen were implored to "follow your section leader and never leave him."

Flatley continued: "It is a proven fact that our VF working together can handle four times as many Japs." In a "general melee" all fighters would remain in the general airspace "shooting Japs off each other's tails with the sections invariably in formation throughout." Once the Japanese scattered, fighters were to avoid diving in pursuit unless the entire formation pursued the fleeing Japanese together. Before diving after Japanese aircraft, American fighters were to beware of decoys at the same altitude or below, and were reminded "always look above, ahead, behind, and on both sides before diving down." If an American fighter made a diving attack and missed because the enemy pulled up sharply, the American was to avoid following him and instead use his diving speed to open the distance and climb before returning to the action. Fighters were to "clear the immediate air, rejoin in teams, and look for more meat." Tactical instructions encouraged pilots that "If you will make yourself keep 160 knots minimum you will shoot down many planes and return to your base. You will have plenty of gas for one-half hour of full power operation…"

Steep 45-plus degree strafing/bombing attacks required a pull-out in time to be departing by 1,000 feet altitude. Pilots were to strafe only once they knew they had a hittable target and never fire longer than a 6-second burst. Aircrew were reminded that "a well-placed strafe will chew up an airplane on the ground even if it doesn't burn," and were warned "Do not make repeated strafing runs on the same objective without retiring out of range (2,500 yards) of automatic AA. Preferably out of sight."

Each US bomber strike would coincide with or

In accordance with Cdr Flatley's memorandum for Operation "Jamboree," *Bunker Hill* Avengers and Helldivers (below) fly in a tight defensive formation during the February 1945 strikes. As *kamikaze* attacks increased, Avengers and Helldivers were steadily replaced in carrier air groups by increasing numbers of versatile Hellcat and Corsair fighter-bombers, and heavier fighter escort made tail-gunners redundant. By 1944 US carrier pilots were beginning to push for a single-seat bomber, which arrived postwar as the powerful AD-1 Skyraider. (World War II Database)

immediately follow planned fighter sweeps. Bomber pilots would be well-briefed before their missions to seek planned approach routes to the target determined by prior analysis of Japanese AA sites, and to "stay clear of the base of clouds if over AA positions." Formations were to remain tight in order that air-gunners could support each other, and the strike's designated fighter escort could more easily cover them. Bomber pilots were encouraged to weave to make themselves harder targets for Japanese fighters.

Once the target was sighted, bombers were to make their attack runs quickly and dive from a slightly different angle from the plane in front of them. Diving attacks were to be aggressive and continue through to the target – early pull-ups meant a bomber would likely find itself separated from the rest of the formation and unable to successfully rejoin. If separated and alone, "seek cloud cover and resort to your combat attitude instrument flying to extricate yourself. Join the first friendly plane you see." Once the attack was concluded, bombers were to recover toward the pre-designated retirement course or rendezvous point. A speedy rendezvous would facilitate mutual support from the bombers' defensive guns and allow the formation to be more easily covered by the fighter escort.

CONCLUSION

As late as 1941, the USN considered the fast carrier as a promising but vulnerable and immature supporting weapon for the battleships, best employed in ones and twos as high-speed raiders. By 1944 the entire paradigm had changed, with fast battleships now supporting up to 17 fast carriers in a single, dominant, carrier-centered Task Force. Three main factors had produced this revolution in military affairs.

Firstly, in late 1941 carrier aircraft suddenly overtook battleships in their ability to accurately deliver ship-killing ordnance, and at 15 times the range. Secondly, the USN developed a comprehensive mobile logistics system that transformed carriers from raiding weapons into the offensive spearheads of sustainable full-scale campaigns; by 1944 US carriers could show up in enemy waters, and stay there. The final element was the timely introduction and quick operational mastery of surface-search and air-search radar. These virtually eliminated both the risk of enemy surface ships getting within gun range of carriers, and of surprise enemy air strikes. Radar-assisted station-keeping also allowed high speeds and tight cruising formations under all conditions, concentrating anti-submarine screens and anti-aircraft fire. Radar-directed AA guns and radar-tipped proximity-fuze ammunition greatly increased anti-aircraft efficiency.

The Fast Carrier Task Force of 1943–1945 represented an extraordinary confluence of weapons, technologies, and doctrine that coalesced at exactly the right time. Virtually every constituent element had already been under construction or development in 1941, belying the myth that it was Pearl Harbor's shattered battleships that forced a reluctant USN to reorganize around carrier tactics. The Fast Carrier Task Force could not have existed without the foresight and cooperation of the US Navy, the federal government, and the American scientific and engineering communities. It was the product of industrial-era, mass-production America at its technological and organizational zenith. However, forging the raw material – human and machine – into an overwhelmingly powerful new weapon system was only accomplished through painfully gained wartime combat experience.

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Main abbreviations used in this text

AA	anti-aircraft
ASW	anti-submarine warfare
avgas	aviation gasoline
CAG	carrier air group
CAP	combat air patrol
CIC	combat information center
FCTF	Fast Carrier Task Force
FDO	flight deck officer *or* fighter direction officer
IJN	Imperial Japanese Navy
IJNAF	Imperial Japanese Naval Air Force
LSO	landing signals officer
OTC	officer in tactical command (of Task Force or Group)
RAF	Royal Air Force (British)
RN	Royal Navy (British)
TF	Task Force
TG	Task Group (subordinate to TF)
XO	executive officer (second in command)

Distances are given in nautical miles:
1 nautical mile (nm) = 1.15 statute miles or 2,025.4 yards
Speeds are in knots, i.e. nm/ph, for example:
10 knots = 11.5 mph
25 knots = 28.78 mph
35 knots = 40.27 mph